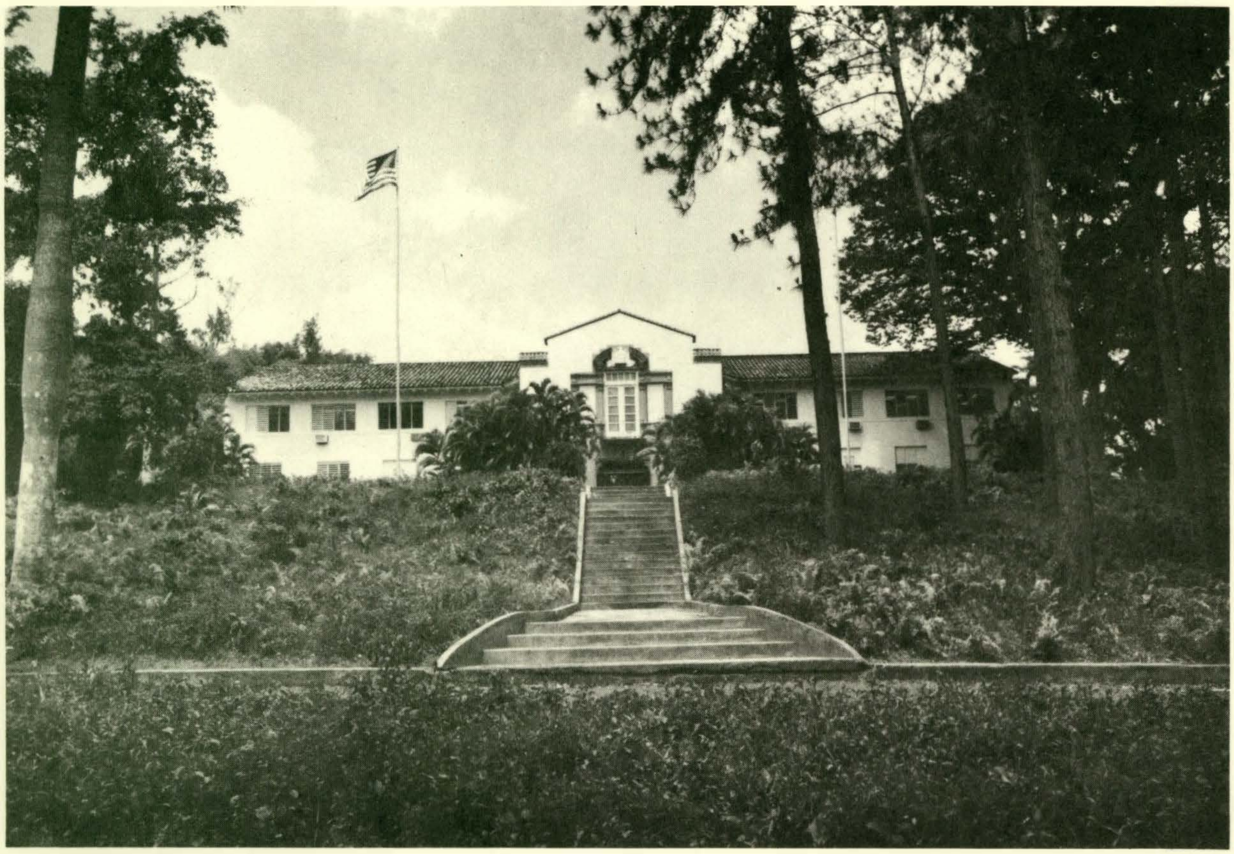
ANNUAL LETTER

1986-87



INSTITUTE OF TROPICAL FORESTRY

RIO PIEDRAS, PUERTO RICO

SOUTHERN FOREST EXPERIMENT STATION

ANNUAL LETTER

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INSTITUTE OF TROPICAL FORESTRY

RIO PIEDRAS, PUERTO RICO

SOUTHERN FOREST EXPERIMENT STATION

Southern Forest Experiment Station
Institute of Tropical Forestry
Call Box 25000
Río Piedras, Puerto Rico 00928
September 1987

Dear Friends:

This Annual Letter reports the progress of the Institute of Tropical Forestry for the period of October 1, 1986 through September 30, 1987. During this fiscal year the Institute's research program produced a record number of publications. Thirty six papers appeared in the literature this year and are listed in the appendix along with other available reprints for public distribution.

One of the Institute's publications was the proceedings of the third meeting of Caribbean foresters, held in Guadeloupe. Meetings of Caribbean foresters occur every two years and the next one is scheduled for Dominica in April, 1988. The theme of the meeting in Guadeloupe was forest recreation and the upcoming meeting in Dominica will focus on wildlife management. Institute staff has been instrumental in the organization of these meetings and are collaborating with the Caribbean National Forest and the government of Dominica in the planning of the next one.

There were several personnel changes in the scientific staff this past year. Dr. Jan Kalina returned to Africa to conduct wildlife research in Kenya. Drs. Ernesto Medina and Elvira Cuevas finished their year visit to the Institute after conducting research in mahogany plantations, the dry forest, pine plantations, mangroves, and secondary forests. Future Annual Letters will report the results of these studies. The Institute recruited Dr. Fred N. Scatena to lead the new watershed program. Some of the progress in this program is reported herein. Wayne Arendt received approval for a one year training grant to conduct studies towards a doctoral degree at the University of Wisconsin, and Peter Weaver completed his doctoral degree at Michigan State University.

This Annual Letter was prepared on our new Macintosh desk-top publishing system which represents a considerable leap in technology since September 1983, when the first computer was used to prepare an Annual Letter. As we continue to adapt to technological innovation we thank all of you who made our program in 1986-87 a busy and successful one (Tables 1-3 at the end of the Annual Letter). Also, I want to announce that on May 25-26, 1989, the Institute will celebrate its golden anniversary with a scientific symposium. We are also planning many other activities for the 50th anniversary. I will keep you informed of these as plans develop.

Thank you and keep in touch!

Sincerely,

Ariel E. Lugo

ARIEL E. LUGO
Director and Project Leader

Estación Experimental Sureña
Instituto de Dasonomía Tropical
Call Box 25000
Río Piedras, Puerto Rico 00928-2500
septiembre 1987

Queridos amigos:

Esta Carta Anual les informa el progreso del Instituto de Dasonomía Tropical para el período del 1 de octubre de 1986 al 30 de septiembre de 1987. Durante este año fiscal, el Programa de Investigación del Instituto produjo un número récord de publicaciones. En el apéndice de este documento se indican treinta y seis (36) artículos impresos, así como otros reimpresos disponibles para la distribución.

Una de las publicaciones del Instituto fue el Acta de la Tercera Reunión Forestal del Caribe, llevada a cabo en la isla de Guadalupe. Estas reuniones forestales del Caribe se llevan a cabo cada dos años, la próxima está programada para el mes de abril de 1988 en la isla de Dominica. En la reunión de Guadalupe el tema fue la recreación forestal, la reunión programada en Dominica enfocará el tema de manejo de la fauna silvestre. El personal del Instituto ha contribuído a la organización de estas reuniones y están colaborando con el Bosque Nacional del Caribe y el gobierno de Dominica en la planificación de la próxima reunión.

Este año hubo algunos cambios en el personal científico. La Dra. Jan Kalina regresó a Africa para llevar a cabo investigaciones de la fauna silvestre en Kenya. Los Dres. Ernesto Medina y Elvira Cuevas terminaron su año de licencia en el Instituto después de llevar a cabo investigaciones en plantaciones de pino, manglares y bosques secundarios. En cartas anuales futuras informaremos los resultados de estos estudios. El Instituto reclutó los servicios del Dr. Fred N. Scatena para dirigir el nuevo programa del manejo de cuencas hidrográficas. El progreso obtenido en este programa esta incluído en esta edición. Al Sr. Wayne Arendt le fue aprobado un año de adiestramiento para conducir estudios hacia un grado doctoral en la Universidad de Wisconsin y Peter Weaver completó su grado doctoral en la Universidad del Estado de Michigan.

Esta Carta Anual se preparó en nuestra nueva procesadora Macintosh, la cual representa un considerable salto en la tecnología desde septiembre de 1983, cuando se usó la primera computadora para preparar la Carta Anual. Así que continuamos adaptándonos a la innovación tecnológica. Le damos gracias a todos aquellos que hicieron de nuestro programa en el 1986-87 uno muy activo y lleno de éxitos (Tabla 1-3 al final de esta Carta Anual). Quiero aprovechar esta oportunidad para anunciar que el 25-26 de mayo de 1989 el Instituto celebrará, con un simposio científico, su aniversario de oro. Estamos planificando otras actividades para este 50mo. aniversario. Les mantendré informados según progresen los planes.

Muchas gracias y mantengámonos en contacto.

Atentamente,

Ariel E. Lugo

ARIEL E. LUGO
Director y Líder de Proyecto

INSTITUTE OF TROPICAL FORESTRY ANNUAL LETTER

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CARTA ANNUAL DEL INSTITUTO DE DASONOMIA TROPICAL

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PLANTATION FORESTRY RESEARCH

John K. Francis
Research Forester

Over the last half century, a large number of small trial and production plantations of exotic and native forest species have been established in Puerto Rico. Many of the species tried have failed or grown slowly, but several have developed impressively. Last year I reported on the development of several tropical conifers of the genus *Araucaria* and the African mahoganies (*Khaya* spp.). Here, I summarize the state of knowledge on 5 species for which work was completed this year.

Enterolobium cyclocarpum or guanacaste is native to Central and Northern South America, but has been planted as a shade tree in Puerto Rico for many years. Probably the largest tree in Puerto Rico is a guanacaste in Mayaguez that is 39 m tall and 2.4 m in diameter. Although open-grown trees have boles only about 2 m long, in closed stands clear boles may reach 10 m or more. The species is easily reproduced and is adapted to nearly the entire range of local climate and to all but the wet soils. The heartwood is a rich brown and resists dry wood termites and decay.

Maesopsis eminii, whose accepted common name is musizi, is native to equatorial Africa. In the home range, this species is a quick-growing colonizer of clearings and heavily disturbed forest, the fruited seeds being widely dispersed by birds and animals. In Puerto Rico, natural reproduction from the original plantations (1962) is now fruiting heavily and seed is beginning to be carried at least hundreds of meters away from mother trees. Indications are that the species will be mostly confined to secondary forests in humid parts of the island. It is adapted to nearly all relatively fertile (but not wet) soils. Musizi has good form and prunes very well. It is capable of producing logs 0.5 m thick in 20 to 25 years. The wood is milk chocolate brown, of medium density, and easily seasoned and worked into lumber, paper, and other useful items. Musizi wood is not termite or decay resistant.

Terminalia ivorensis, idigbo, is a beautiful and stately tree of equatorial Africa. It is self pruning and has exceptional form. Two small plantations in Puerto Rico have done well; dominants gaining a meter of height and nearly 2 cm of diameter per year. Both have reproduced, although the seed has not traveled far from mother trees. The species appears to be widely adapted to humid site on the island. Idigbo wood is lusterous yellow and valuable in international trade. It is not rot resistant but may be somewhat resistant to termites.

Hernandia sonora, known locally as mago, is native to Puerto Rico as well as several other countries boardering the Caribbean. Mago has also been planted successfully on a number of sites on the island. It is established easily and grows with long clear boles. The species will grow, at least slowly, on all types of soils where it has been tried. It seems to require at least 1250 mm of annual precipitation in upland sites. Mago makes its best growth along streams in the Luquillo Mountains where there are individuals approaching 40 m tall and exceeding 1 m in diameter. The wood is of moderately low specific gravity and not currently marketable. Perhaps it might be used in flakeboard or similar products.

Hibiscus elatus, commonly called mahoe, is native to Jamaica and Cuba, but has been planted widely in humid forests of the island, generally with spectacular success. Mahoe is adapted to most soils in humid areas of Puerto Rico and reproduces aggressively. Growth is rapid. On good sites, dominants reach 28 m tall in 20 years and if given enough room to grow will have about 40 cm diameter in 25 years. The boles prune well but are sometimes subject to heavy epicormic branching. Mahoe can maintain 40 to 70 m^2/ha basal area and produce 10 to 25 m^3/ha of wood per year. The wood is easily worked and has a wide range of uses.

The plantation surveys continue. Current work in centered on *Fraxinus uhdei*, *Pterocarpus macrocarpus*, *Tectona grandis* and the eucalypts.

COOPERATIVE STUDIES ON CARIBBEAN PINE PLANTATION MANAGEMENT

Leon H. Liegel
Soil Scientist

Work begun in 1983 under US-AID auspices (see previous Annual Letters) for *Pinus caribaea* is in the final stages of completion. Cooperating countries include Costa Rica, Jamaica, Puerto Rico, Trinidad, and Venezuela.

Data from over 160 field plots were analyzed in cooperation with biometricians from our Institute for Quantitative Studies in New Orleans. Growth models have been prepared which predict total yields (overbark, m^3/ha) from plot age, for three planting densities; show site index estimates, for base age 15 years; and predict the number of trees surviving per ha at different ages, based on three planting densities.

Poor growth at non-research plot sites was generally attributed to specific management practices (e.g., poor nursery stock, field planting problems, lack of silvicultural treatment) rather than to physical/chemical properties of soils. Yield differences between soil/geological or life zone regions were not generally significant within any country.

Over half of the original grant ($150,000) was used for training and forestry institution-building activities outside Puerto Rico. In all, 23 individuals were sent on 12 separate training exercises, ranging from one week to six months duration.

COOPERATIVE WORK WITH YALE UNIVERSITY

John A. Parrotta
Center for Energy and Environment Research
US Department of Energy

Intensive management of biomass plantations for energy and livestock fodder using fast-growing tree species often involves substantial harvest-related export of nutrients. Over the long term, these losses may result in productivity declines due to nutrient limitations, particularly on marginal sites commonly allocated for such plantations in many tropical countries. The Toa Baja Bio-Energy Plantation Project was initiated in 1984 to assess the influence of initial spacing and stand age on production and nutrient uptake and storage in high-density forest plantations in Puerto Rico (Parrotta 1987a).

Albizia lebbek, the species chosen for study, is a nitrogen-fixing, semideciduous tree species suited to a wide range soil conditions in a variety of semiarid and moist tropical and subtropical environments. It is a popular species for reforestation and fuelwood plantation developments worldwide (Parrotta 1987b). Planting stock for this experiment consisted of four-month-old seedlings of *Albizia lebbek* produced from seeds collected near Ponce, Puerto Rico from a single parent tree. Plantation plots were established in November 1984 at stocking rates of 2,500, 10,000, and 40,000 trees/ha. The plantation site, located approximately 10 km west of San Juan, is characterized by deep, well-drained, moderately alkaline (pH 7.9 to 8.4), calcareous sands poor in organic matter, and several plant nutrients (Parrotta 1987a).

Individual tree growth rates, stand development characteristics, total tree biomass production, biomass partitioning and nutrient allocation patterns were assessed for each density treatment during the first three years of plantation development. Results for 36-month-old stands are summarized in Tables 1 and 2; earlier findings were presented and discussed elsewhere (Parrotta 1987a, c).

At 36 months, mean tree heights were 4.4, 3.7, and 2.4 m and mean basal stem diameters 7.5, 4.9, and 2.6 cm in the low, intermediate and high density treatments, respectively. Corresponding mean tree aboveground

Table 1. Mean tree growth parameters and stand characteristics for 3-year-old *Albizia lebbek* plantation plots at Toa Baja, Puerto Rico. Values represent density treatment means ± standard error (n = 107).

	Initial stand density (trees/ha) 2,500	10,000	40,000
Tree height (m)	4.350 ± .118	3.734 ± .136	2.366 ± .116
Stem diameter (cm)	7.516 ± .316	4.898 ± .253	2.583 ± .146
Crown width (m)	3.342 ± .116	2.313 ± .107	1.108 ± .073
Crown depth (m)	1.953 ± .082	1.409 ± .075	0.648 ± .045
Standing biomass (tons/ha)			
leaves	2.88	4.36	4.32
branches/stems	18.85	25.14	14.40

Table 1. (cont'd)

	Initial stand density (trees/ha)		
	2,500	10,000	40,000
aboveground	21.73	29.50	18.72
roots	12.95	20.71	25.51
total biomass	34.68	50.21	44.23

biomass at three years was 8.69, 2.98, and 0.48 kg. At three years, total aboveground biomass yields were estimated to be 21.7, 29.5, and 18.7 Mg/ha (oven-dry weight) in the low, intermediate and high density treatments, respectively (Table 1). Total nutrient content per unit of total aboveground tree biomass (for N, P, K, Ca, and Mg) was substantially higher in the higher density treatments than could be accounted for by productivity differences alone (Table 2). Density-related differences in "unit nutrient costs" (kg nutrient per unit of biomass yield) were linked to treatment differences in tree morphology and the proportion of nutrient-rich leaf, twig and bark tissues comprising aboveground biomass.

Results to date from this study suggest that increased harvestable biomass yields and reductions in both "unit nutrient costs" and total nutrient export rates could be realized through a combination of lower stand densities, longer rotation times and less intensive harvest practices.

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Parrotta, J.A. 1987b. *Albizia lebbek* (L.) Benth. Silvics of Forest Trees of the American Tropics. SO-ITF-SM-7. USDA Forest Service, Southern Forest Experiment Station, Institute of Tropical Forestry, New Orleans, LA.

Parrotta, J.A. 1987c. The influence of management practices on the biogeochemical stability of tropical fuelwood plantations in Puerto Rico. Proceedings IX International Symposium on Tropical Ecology, Varanasi, India. (in press).

Table 2. Estimated aboveground biomass nutrient content and potential nutrient losses per unit of biomass yield ("unit nutrient costs") for total aboveground biomass (WT = whole tree) and branch + stemwood - only (Br/St) harvest and removal for *Albizia lebbek* stands at 36 months.

	Initial stand density (trees/ha)					
	2,500		10,000		40,000	
Aboveground biomass nutrient content (kg/ha)	WT	Br/St	WT	Br/St	WT	Br/St
Nitrogen	384	277	533	371	378	217
Phosphorus	23.8	18.7	32.7	25.0	22.2	14.6
Potassium	108	80	149	105	104	60
Calcium	184	116	258	156	197	96
Magnesium	22.5	17.6	31.6	24.1	22.7	15.3
"Unit nutrient cost" (kg/Mg biomass yield)						
Nitrogen	17.7	14.7	18.1	14.8	20.2	15.1
Phosphorus	1.09	0.99	1.11	0.99	1.19	1.01
Potassium	4.97	4.24	5.06	4.18	5.56	4.19
Calcium	8.45	6.15	8.75	6.20	10.5	6.67
Magnesium	1.04	0.93	1.07	0.96	1.21	1.06

RESEARCH IN NATURAL FORESTS

Peter L. Weaver
Research Forester

Secondary Forests

In 1980, an inventory of Puerto Rico's secondary forest resources was conducted. In 1985, a subsample of the original permanent plots was used to determine changes in forest area (Birdsey and Weaver 1987). Total forest area in Puerto Rico increase from 279,000 ha in 1980 to 300,000 ha in 1985. Most of the new forest was growing on abandoned pasture. Secondary forest and abandoned coffee shade accounted for 76 percent of all forest land. Xeric scrub and active coffee shade accounted for 11 and 10 percent, respectively, of all forest land.

Soil organic matter and loose litter were also studied in secondary forests according to life zone (climate), type of forest cover, soil group, and topography (Weaver et al. 1987). Soil organic matter content in the top 23 cm was greater in the moist forest than in the wet forest. Greater amounts of soil organic matter were also found under higher timber volumes, a trend that was less pronounced in the wet forest. Significant interactions were found for organic matter among soil groups (deep volcanic, shallow volcanic, granitic, and limestone) and among forest classes (young secondary, late secondary, abandoned coffee, and active coffee shade). Moreover, highly significant differences were observed by landform and slope in active coffee shade in wet forests, with the lowest levels of organic matter where landforms are convex and where slopes are greater than 45 percent. Mean loose litter storages in moist and wet forests were not significantly different, nor was there a significant interaction with life zone. Significant differences, however, were detected by timber volume class, life soil group, and forest class. Within these highly disturbed wet and moist forests, greater timber volumes tended to be associated with greater loose litter accumulation.

Management opportunities for secondary forests is of vital concern because they are increasing at a rapid rate. The 1980 Puerto Rican forest inventory showed that nearly 60,000 ha of coffee shade covered the interior mountains. Within these stands, 34 timber species were identified. Coffee shade forests may be managed in several ways depending on the objectives of the farmer and the composition of the coffee shade stand. Among the opportunities are greater intercropping (agroforestry), taungya plantings (interspersing subsistence crops with timber), thinning, enrichment planting, or the establishment of closed plantations. A flow chart of management alternatives emphasizing agroforestry and timber production has been developed (Weaver and Birdsey 1986). Alternatives for management of secondary forest for timber products have also been discussed (Weaver 1986a).

Management alternatives for secondary forests include enrichment plantings (line planting, limba, mafuku mounds, Anderson planting, gap planting, underplanting, and other techniques). At least 163 tree species in at least 12 neotropical countries have been used for enrichment plantings on an experimental basis (Weaver 1986b). In three countries, these plantings have been tried on a management scale. About 25 of the species tested proved suitable for planting by enrichment techniques. Unfortunately, enrichment plantings have a poor reputation largely because of poor establishment and maintenance practices. Biological, economic, and environmental arguments can be forwarded in favor of the technique. Of the several different methods used, conversion line planting appears the best.

Luquillo Forest

Cyrilla racemiflora L. (cyrilla, swamp cyrilla, or titi) occurs naturally from Virginia (United States) through the Antilles to northern Brazil. Throughout most of its range, cyrilla is a small tree, but in the mountains of the Antilles, it occasionally reaches diameters of 2.5 m or more.

The existence of long term growth data for several plots within the Luquillo Forest allowed the investigation of cyrilla's ecology. The use of arithmetic techniques to estimate age disclosed that a 1 m tree was about 660 years old (Weaver 1986c). Moreover, exceptionally large trees appeared to be the product of coalescence of closely spaced individual stems. Finally, the regeneration of cyrilla was correlated with past disturbance in the Luquillo Forest. A disproportionate number of stems were in the 30 to 40 cm class which developed following three hurricanes which directly hit Puerto Rico between 1766, and 1772.

Structure and dynamics in the colorado forest (lower montane wet and rain forests, sensu Holdridge) of

the Luquillo Mountains were described in three chapters of a dissertation (Weaver 1987). The first concerned changes in forest structure and growth after hurricane disturbance. The second dealt with structure and composition of closed canopy colorado forest relative to environmental gradients. The last chapter was mainly on forest productivity. Changes in forest structure and growth after hurricane disturbance were summarized in last year's annual letter (see also Weaver 1986d, e, f). More detailed descriptions of species site relationships and productivity will be forthcoming in subsequent annual letters as the individual papers are published.

St. John and Hassel Island, U.S. Virgin Islands

St. John Island, one of the three main US Virgin Islands, is 5180 ha in size, and Hassel Island, located in Charlotte Amalie Harbor, is 55 ha in size. Three-quarters of St. John and virtually all of Hassel are under the jurisdiction of the US Park Service.

Survey of the island disclosed 10 vegetation types using Beard's terminology with some modification: mangroves and adjacent areas, three moist forests (upland, gallery, and basin), four dry forests (evergreen, thicket-scrub, thorn-cactus, and rock pavement-coastal hedge), secondary vegetation, and pasture (Woodbury and Weaver 1987). All species were classified according to forest types and life forms (tree, shrub, vine, herb, epiphyte). Relative abundances of all species (rare, occasional, frequent, common) were indicated by forest types. Eighteen rare and endangered species were found and located on base maps. Six of these species may be new to science.

A brief text provided environmental data for the islands and outlined environmental concerns and management recommendations. Maps were produced dilineating all vegetation types. A herbarium collection of all specimens was submitted to the Park Service.

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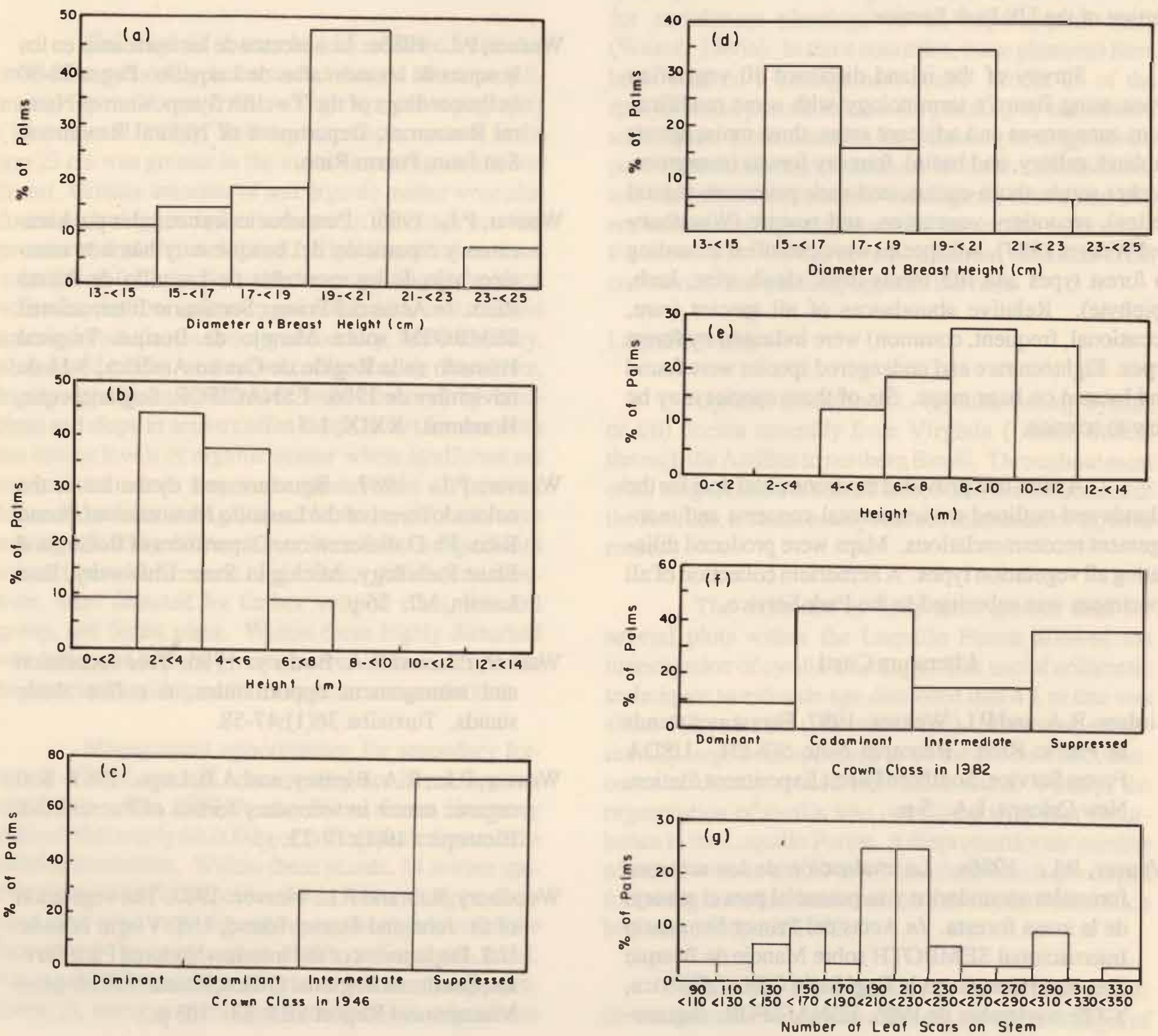
OTHER STUDIES IN NATURAL FORESTS

Ariel E. Lugo
Research Ecologist

The assumption that landscapes dominated by mature vegetation are presently in carbon steady state with the atmosphere was challenged (Lugo and Brown 1986). Evidence suggests that the vegetation and soils of these landscapes are frequently disturbed and over short time periods (<300 yr) slowly sequester atmospheric carbon. The critical consideration in this argument is the time interval used to evaluate a steady state. Current models of carbon flux through the terrestrial biota limit their time considerations to 120 yr, a short and inadequate time interval for realistic assumptions about steady state in the carbon cycle of vegetation.

Long-term growth rates of 32 palms (*Prestoea montana*) were studied using height and diameter measurements taken four times between 1946 and 1982 (Lugo and Rivera Battle 1987). All leaf scars were counted to estimate leaf production rate, and the distance between scars was measured to establish relationships between leaf production and height growth. Height and diameter growth and leaf production of this palms were not constant during this 36-year period (Fig. 1). A greater distance between leaf scars was indicative of rapid height growth but not of high leaf production rate. Palms that became dominant always grew fast (>20 cm/yr) in



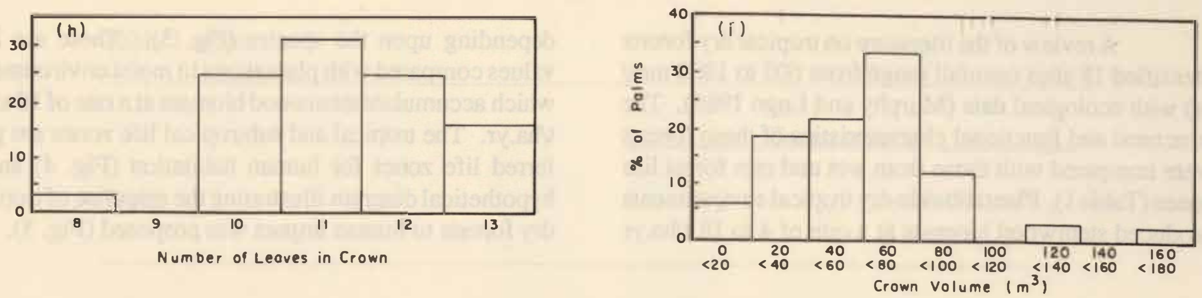


Figure 1. Frequency diagrams of the dimensions (a, b, d, and e), crown characteristics (c, f, and h), and number of leaf scars (g) for 32 individuals of the sierra palm *Prestoea montana* in the Luquillo Experimental Forest. Values for 1946 are given in a to c and for 1982 d to i.

height when they were young, but height growth slowed down when they reached the canopy. Small palms with slow height growth remained suppressed and lost the capacity to grow rapidly in height as adults. Diameter growth decreased with age from 0.07 cm/yr (SE = 0.02) between 1946-51 to 0.01 cm/yr (SE = 0.003) between 1951-82. Annual leaf production averaged 4 leaves/yr over the 36 years of study, was significantly different ($P = 0.001$) between 1946-51 (5.6 leaves/yr) and 1951-82 (3.8 leaves/yr), and was 4.6 leaves/yr for dominant palms that grew >5 m since 1946 and 3.7 leaves/yr for those that remained suppressed. The best estimate for the mean age of all palms was 61.1 yr (SE = 2.4), obtained from long-term population leaf production rates (Fig. 2). Members of the dominant age class were seedlings or young palms in 1932 when a killer hurricane struck the forest.

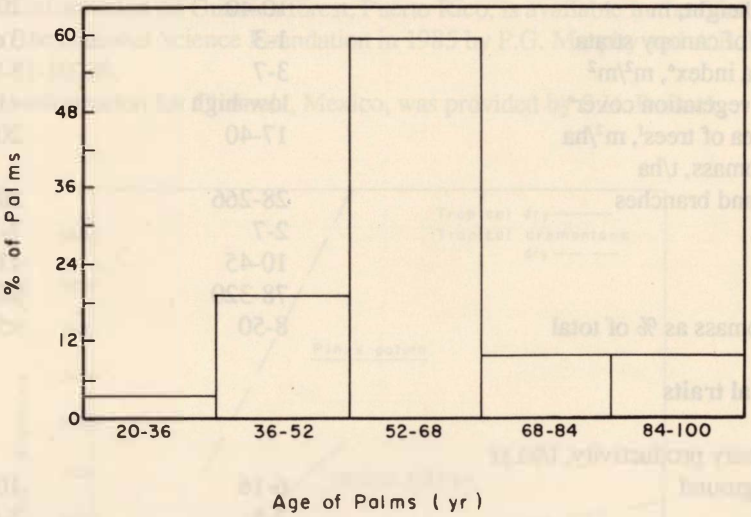


Figure 2. Frequency diagram of age groups in 32 individuals of the sierra palm *Prestoea montana* in the Luquillo Experimental Forest.

A review of the literature on tropical dry forests identified 18 sites (rainfall range from 603 to 1800 mm/yr) with ecological data (Murphy and Lugo 1986). The structural and functional characteristics of these forests were compared with those from wet and rain forest life zones (Table 1). Plantations in dry tropical environments produced stemwood biomass at a rate of 4 to 18 t/ha.yr depending upon the species (Fig. 3). These are low values compared with plantations in moist environments which accumulate stemwood biomass at a rate of 10 to 30 t/ha.yr. The tropical and subtropical life zones are preferred life zones for human habitation (Fig. 4) and a hypothetical diagram illustrating the response of tropical dry forests to human impact was proposed (Fig. 5).

Table 1. Structural and functional characteristics of tropical and subtropical dry forest[a] relative to tropical and subtropical wet and rain forest[b]

Traits	Forest type: Dry[a]	Forest type: Wet[b]
Structural traits, community level		
Number of tree species[c]	35-90	50-200
Complexity index[d]	5-45	180-405
Canopy height, m	10-40	20-84
Number of canopy strata	1-3	3 or more
Leaf area index[e], m^2/m^2	3-7	5-8
Ground vegetation cover[e]	low-high	<10%
Basal area of trees[f], m^2/ha	17-40	20-75
Plant biomass, t/ha		
Stems and branches	28-266	209-1163
Leaves	2-7	7-10
Roots	10-45	11-135
Total	78-320	269-1186
Root biomass as % of total	8-50	<5-33
Functional traits		
Net primary productivity, t/ha.yr		
Aboveground	6-16	10-22
Roots	2-5	3-6
Total	8-21	13-28
Fine litter production[e], t/ha.yr	3-10	5-14
Tree diameter growth[e], mm/yr	1-2	2-5 or more
Growth periodicity[e]	1-2 pulses annually	continuous or intermitent
Foliage persistence[e]	deciduous & evergreen	primarily evergreen
Reproductive phenology[e]	seasonal & aseasonal	less seasonal
Successional traits		
Resistance to disturbance	low	high
Resilience, overall	high	low
As % original height[e], 1 yr	9-14	7-10

Table 1. (cont'd).

Traits	Forest type	
	Dry[a]	Wet[b]
Taxonomic recovery rate[e]	high	low
Overall recovery, years	150+	1000
Plant ht. growth[e], m 1 yr	1-3	2-5
Leaf area index[e], m^2/m^2, 1 yr	2-3	4-5
Leaf area index uniformity[e]	patchy	more uniform
Vegetation cover[e], %, 1 yr	90	100
Importance of coppicing[e]	high	less
Soil seed pool longevity[e]	short to long	relatively short

[a]Annual rainfall 500-2000 mm; strongly seasonal; annual PET/P normally >1.
[b]Annual rainfall >2000 mm; litter or moderate seasonality; annual PET/P nornmally <1.
[c]Based upon surveys of 1-3 ha; includes trees at least as small as 10 cm dbh.
[d]Calculated as the product of number of species, basal area (m^2/0.1 ha), maximum tree height (m), and number of stems/0.1 ha, times 10^{-3} in a 0.1 ha plot
[e]Unpublished information on Guánica forest, Puerto Rico, is available in the final report submitted to the National Science Foundation in 1985 by P.G. Murphy and A.E. Lugo; Grant DEB-81-10208.
[f]Unpublished information for Chamela, Mexico, was provided by S.H. Bullock.

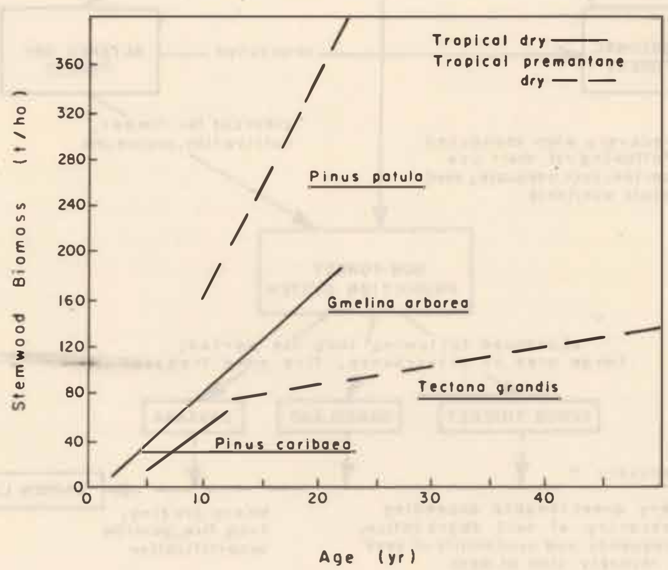


Figure 3. Stemwood biomass accrual in tree plantations of tropical dry and tropical premontane dry life zones. Data compiled by the Institute of Tropical Forestry, Río Piedras, Puerto Rico.

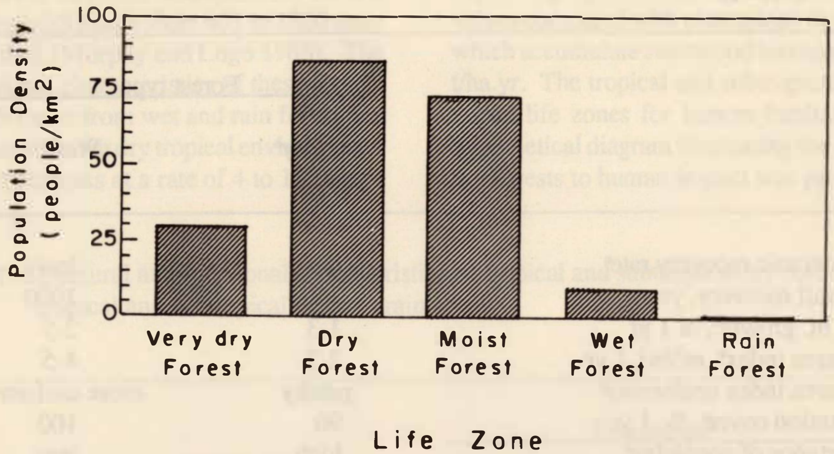


Figure 4. Average population density by life zone in five Central American countries. Based on data from Tosi and Voertman.

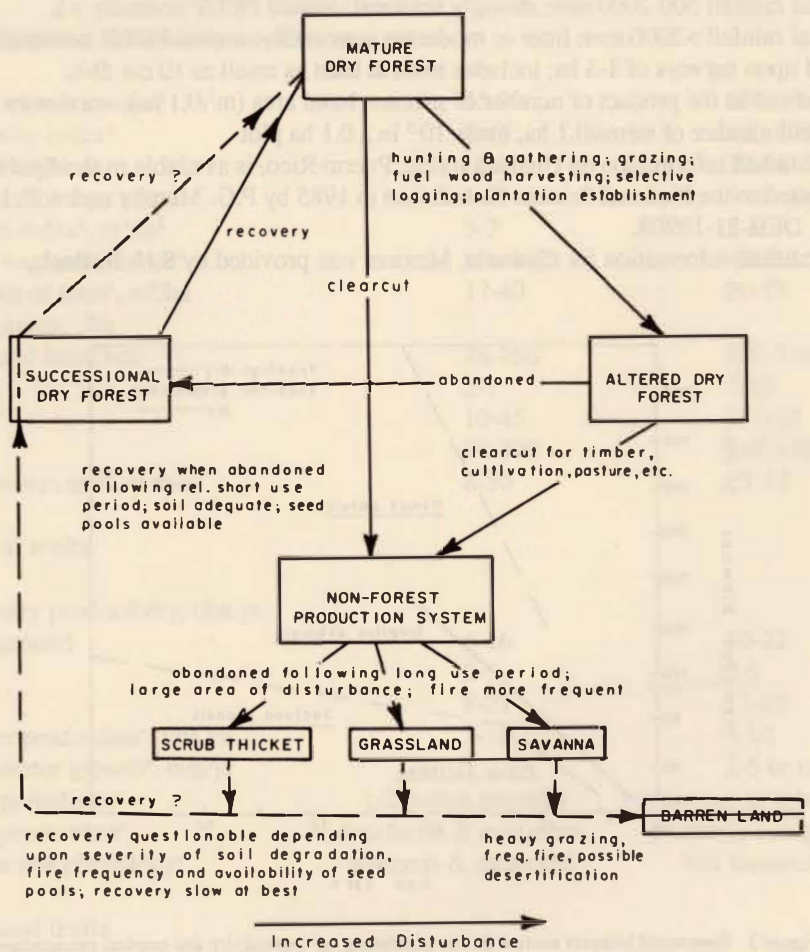


Figure 5. Hypothetical response of dry forest to human impact.

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SPECIAL STUDIES

Frank H. Wadsworth and Julio C. Figueroa
Research Forester and Botanist

Book on Forest Production

The manuscript for the book "Forest production for Tropical America" has been edited and is currently under review by two veteran international forestry educators. It should be ready for submittal to the Government Printing Office in 1988.

Tree Growth Trends

Continued analysis of long-term growth in the Sierra de Luquillo has led to a number of conclusions concerning the response of trees to microenvironment. An intensive analysis has been undertaken for 1470 trees of 14 timber species in forests between 200 m and 600 m elevation with mean annual rainfall from 200 to 650 cm, and on acid clay ultisols and inceptisols.

Topography is significant to the occurrence and productivity of the trees in primary stands of this forest. Of the total number of trees 10 cm dbh or more, 49% were on ridges and only 11% in valley bottoms. The number on ridges exceeds the areal representation of the ridges, leaving less in proportion for the slopes and valley bottoms. Stem diameter growth from 1958 to 1982 was clearly more rapid on bottoms than on slopes and ridges.

The average stand density around each tree in primary forest, determined with prisms, increases as slope sleepness increases (above 40°). Mean total heights for more mature trees (40 cm dbh or more) are also significantly greater for trees on slopes steeper than 40° than for those on lower slopes. A similar, significant superiority of stem diameters was also found for the mean of trees growing in primary forest on slopes over 40°. Mean growth in diameter and basal area increment in primary forest over the 24-year period from 1958 to 1982 was not affected significantly by steepness, but on slopes steeper than 40° there was a tendency of more rapid basal area growth mainly due to the preponderance of large diameter trees.

East facing slopes, exposed to the prevailing winds, are significantly steeper than either those to the north and west. Too few trees on southerly slopes were available for a reliable comparison. In the primary forest, stands were significantly more dense on eastern than on western-facing slopes. Tree heights and diameters apparently are not significantly affected by aspect in the primary forest, but growth in diameter and in basal area increment are both significantly more rapid on north facing slopes than on those facing east.

The ratios between the diameter of tree crowns and their stems averaged 22 but with 3 m the ratios were significantly greater for trees with no competing trees than for those with 80 cm or more in aggregate diameter. Comparisons of both stem diameter growth and basal area increment showed both to be significantly lower in stands with basal areas of 26 m^2/ha or more versus those with less than 12 m^2/ha .

Trees in dominant crown positions averaged 41% more basal area increment from 1958 to 1982 than codominants, 73% more than intermediates and 163% more than those suppressed.

Growth prediction models are being developed. A logarithmic equation with corresponding coefficients for each population, yields high coefficients of determination for the period 1958 to 1982 (Table 1). Annual dbh growth = a (LN dbh) + (LN final crown diameter + c (LN final crown diameter/LN final dbh) + k. Final crown diameters and ratios were used in the absence of initial measurements. They do not simulate exactly the information available for prediction but the fit is good enough to suggest using the same, easily taken measurements, at the beginning of the growth period for further testing.

Table 1. Coefficients of determination and sample sizes for 1958-1982 dbh growth prediction equations in the format given in the text for various tree populations in the Luquillo Experimental Forest. Numbers given all totals for all fourteen species.

Population	N	R^2
Total trees	1401	0.90
Intermediate trees only	348	0.94
Primary forest alone	508	0.85
Intermediate trees only	164	0.92
Secondary forest alone	893	0.93
Intermediate trees only	184	0.96
Dacryodes, intermediate only	85	0.93
Manilkara, intermediate only	32	0.99

WILDLIFE RESEARCH

Wayne J. Arendt
Wildlife Biologist

PUERTO RICAN PARROT AND RELATED RESEARCH

Biotelemetry Studies

The three-agency cooperative effort to monitor the post-fledging mortality, dispersal, movements, and habitat use of yearling Puerto Rican Parrots is well into its third year. The participating agencies are the US Forest Service, US Fish and Wildlife Service, and the Puerto Rico Department of Natural Resources. Eight parrot chicks fledged from three wild nests in 1987. All eight were fitted with radio transmitters before leaving the nest. Despite expected predation, transmitter failure, and occasional disappearance of radioed young, valuable information has been obtained on dispersal, movements, habitat use, and causes of first-year parrot mortality. Although the occasional disappearance of the signals from the entire group of radioed young is due to interference caused by rough topography (deep valleys and tall mountain peaks), this year's periodic extended loss of signals suggests that parrot flocks may be using more remote valleys outside of the traditional parrot areas. This has been a very encouraging finding. The use of new areas for foraging and roosting substantiates the commonly held belief that many more areas of the Luquillo mountains contain suitable parrot habitat that will serve as reintroduction sites once the wild population begins to reach the carrying capacity of the traditional areas. With the use of additional valleys by non-breeding parrots, comes the hope that pioneering nesters will eventually seek out and use nest sites in these new areas. From an evolutionary perspective, this will serve to reduce nest site fixation and thus the problem of inbreeding depression and genetic drift. From an ecological standpoint, the establishment of parrot propagules into new areas of the forest will increase the chances of suvival of at least a portion of the entire population, and will help to protect the gene pool, should the forest suffer extensive damage as a result of natural disasters or anthropogenic disturbances.

Ecology of the Pearly-eyed Thrasher

1987 Breeding Season

The death of the last remaining thrashernestling from an original brood of three nestlings (all victims of heavy dipteran ectoparasitism) on July 26, 1987 marked the official close of this study's ninth year. This year's breeding season data will be compared with that of the other 8 seasons and is currently under analysis.

Thrasher Morphology

One aspect of this study is a comparison of size variation and sexual dimorphism within and among El Yunque and inter-island thrasher populations throughout the Caribbean. Although the bulk of data analyses, accompanying tables and figures, and discussions of the biological and ecological significance of the results will go into a larger and much more comprehensive publication, some of the results of these comparisons are summarized below.

Body mass of the Pearly-eyed thrasher was, with the exception of those on the Island of St. Lucia, directly correlated with island size ($R = 0.93$, $Y = 0.143 + 0.964X$; Fig. 1). Wing chord length varied seasonally and was greatly influenced by molt stage of the primaries

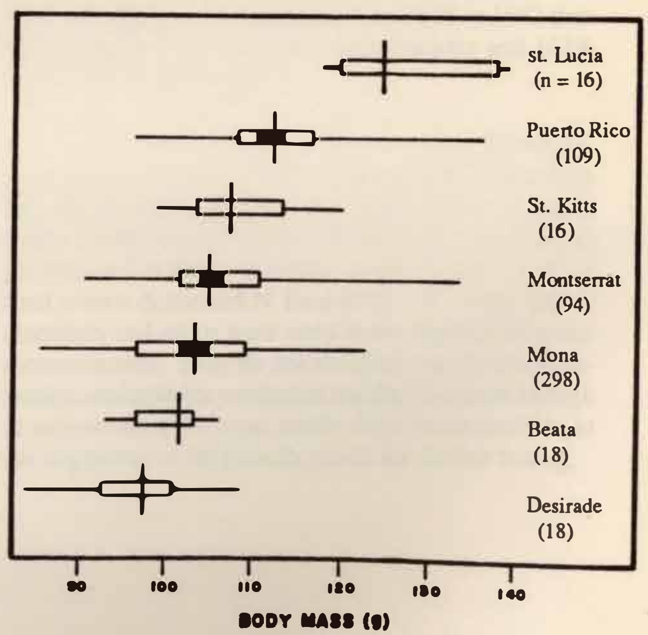

Figure 1. Comparison of body mass of allopatic population of the Pearly-eyed Thrasher on 8 Caribbean islands.

at the time of measurement. Wing chord length varied with elevation and habitat type. The center rectrix was not correlated with overall body size and, thus, was not correlated with island size. The center rectrix showed the same seasonal feather wear as that observed in the primaries. Overall bill size (e.g., exposed culmen, culmen depth and width) was greater in wet forest thrasher populations found on large islands. However, culmen length from the nares was significantly greater in dry forest populations on small islands. Tarsal length, too, was found to be greater in dry forest populations on small islands.

Significant elevational and seasonal differences were found in allopatric thrasher populations within and among islands. Highland wet forest thrasher populations tended to be larger than lowland dry forest populations. Within-season comparisons between highland and lowland thrasher populations resulted in highland individuals measuring larger than lowland individuals in most characters in both the dry and wet seasons. Seasonal variation was minimal in the El Yunque highland wet forest thrasher population, but was more pronounced in both the Guánica and Mona lowland dry forest thrasher communities.

Body mass was also found to vary hourly in this species within and between two populations. Data were analyzed for two Puerto Rican thrasher populations: the El Yunque highland wet forest population and the Guánica lowland dry forest population. Among the four comparisons (Guánica sexes lumped, El Yunque sexes lumped, and El Yunque sexes separated), body mass fluctuated similarly, not only in both dry and wet forest individuals, but also between both sexes of the wet forest population (Fig. 2). There were slight body mass peaks at 1100 and 1500 hrs. Sample sizes of thrashers captured before 0700 were small at both sites and, therefore, the data were not included in Fig. 2. However, the few thrashers that were captured before 0700 in El Yunque and at Guánica (6 and 9 individuals, respectively) were heavier (112 g and 99 g, respectively) than individuals captured between 0700 and 0800, suggesting that there are peaks in body mass about every 5 hr (0600-1100) early in the day, and then every 4 hr (1100-1500) later in the day. These data are consistent with extensive data and foraging behavior of wet forest thrashers taken from observation blinds. Wet forest thrashers forage heavily at dawn, then again just before mid-day, and then again in mid-afternoon.

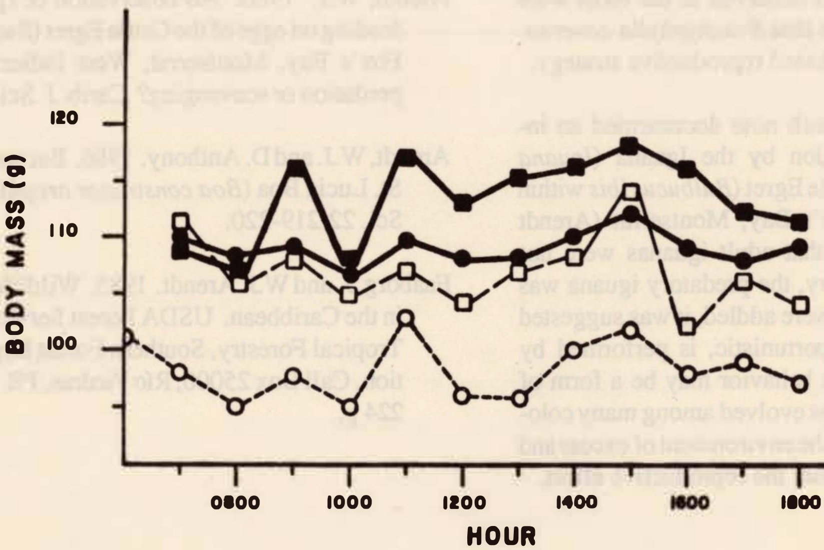

Figure 2. Comparison of hourly fluctuations in body mass of two allopatic populations of the Pearly-eyed Thrasher in Puerto Rico.

El Yunque (wet forest) Females
El Yunque (wet forest) Sexes lumped
El Yunque (wet forest) Males
Guánica (dry forest) Sexes lumped

Sexual size and plumage dimorphism were found in the El Yunque Pearly-eyed Thrasher population. Female thrashers weighed more and had larger bills than males, whereas males had longer wing chords and center rectrices. Ninth primary and tarsal lengths were similar between sexes. Adult males of the El Yunque thrasher population tended to have more pronounced white frosted feathers in the tail and scapular regions, and a more distinct scaling effect of the breast feathers on a pure white background than do females. There were exceptions, however, where the reverse was observed.

Wildlife Assessments

In a series of publications resulting from wildlife assessments in the Eastern Caribbean (Faaborg and Arendt 1985), two research notes appeared this year. The first dealt with an instance of predation by the St. Lucia Boa (*Boa constrictor orophias*) on the bat *Brachyphylla cavernarum* at a tree roost in a "chatagnier" tree (*Sloaena caribaea*) located within the Castries Waterworks Reserve along the Old French Road near Forestiere, St. Lucia (Arendt and Anthony 1986). Although little has been reported on bat predation by snakes at bat tree-roosts, the growing number of observations suggests that such behavior is common in tropical boids. The fact that all of the bats handled and observed at the roost were lactating females, suggests that *Brachyphylla cavernarum* has evolved a harem-based reproductive strategy.

The second research note documented an instance of reptilian predation by the Iguana (*Iguana iguana*) on eggs of the Cattle Egret (*Bulbucus ibis* within a mangrove forest at Fox's Bay, Montserrat (Arendt 1986). Due to the facts that adult iguanas were not observed within the heronry, the predatory iguana was young, and the egret eggs were addled, it was suggested that such predation is opportunistic, is performed by juvenile iguanas, and such behavior may be a form of sanitary predation which has evolved among many colonial breeders in order to rid the environment of excess and waste products resulting from the reproductive effort.

Avian Community Studies

Long-term avian population dynamics studies continue in Puerto Rico and the Dominican Republic. Results from net samples taken at traditional banding sites on both islands in 1987 showed that resident species and total number of individuals dropped slightly, remained constant, or even increased. In contrast, species and total numbers of individuals of North American migrant birds were down considerably in 1987 (Table 1). At the Guánica dry forest banding site, migrant species fell 60% below the previous 12-year minimum, while the total number of migrant individuals equalled the previous 12-year minimum of 8, which occurred in 1981. This is a drop of more than 50% below the 12-year average of 19 individuals in previous years. At the Sánchez mangrove forest net line in the Dominican Republic, the number of migrant species was down about 33%, while the number of migrant individuals was down about 27% (Table 1). Populations of North American migrants will be sampled again on both islands in January of 1988 to closely monitor possible declines in their wintering populations at the two banding sites.

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Table 1. A comparison of 1987 captures with past yearly averages of North American migrant birds at two traditional banding sites, one in Puerto Rico and the other the Dominican Republic.

Guánica dry forest

	Number of species		Number of individuals	
	12-yr mean (min.-max.)	1987	12-yr mean (min.-max.)	1987
Residents	14 (9-17)	11	86 (42-140)	75
Migrants	5 (3-18)	2	19 (8-31)	8

Sánchez mangroves

	December 1984-85 mean (min.-max.)	February 1987	December 1984-85 mean (min.-max.)	February 1987
Residents	6 (6-7)	6	14 (12-16)	21
Migrants	9 (9-9)	6	133 (128-137)	97

PUERTO RICAN PARROT COOPERATIVE RESEARCH

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and

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Introduction

The wild population of the endangered Puerto Rican parrot (*Amazona vittata*) has gradually increased from a low of 14 birds in 1975 to 33 at the beginning of the 1987 breeding season. The captive flock was first established in 1973 in order to provide insurance against a catastrophic loss of the parrot in the wild as well as support for the wild population. The captive flock now stands at 41 parrots. Although progress has been made, both flocks suffer from low reproduction effort and productivity. Research efforts in 1987 focused on monitoring population survival and movements of fledgling parrots and improving reproductive success.

Wild Population

Seven to eight Puerto Rican parrot pairs exhibited territorial behavior during the 1987 breeding season, but only 4 pairs were known to have produced eggs. One of these was a new pair (SF#2) in South Fork, that nested in an area which had not been used since 1973. The 4 active pairs produced a total of 21 eggs. This total included the first clutch of 2 pairs that were induced to lay second clutches (Table 1). All of the wild-produced eggs were fertile with a hatching success of 82% for eggs incubated in the wild nests. Three nests produced fledglings: 8 in the wild and 1 in captivity (Table 1). The National Audubon Society sponsored 6 nest-watch volunteers to assist project personnel in guarding the active nests.

Table 1. Summary of nesting activity of wild Puerto Rican parrots, Luquillo Experimental Forest, 1987.

Nest	No. eggs	No. fertile eggs	No. eggs hatched	No. chicks taken for captive flock	No. fledged in wild
WF	4	4	2	0	2
EF#3	6*	6	0	0	0
SF#1	8§	8	6†	1	3
SF#2	3	3	3	0	3
Totals	21	21	11	1	8

* both clutches were incubated at aviary
§ first clutch of 4 eggs incubated at aviary

In June, the wild population reached a record post-fledging count of 41 parrots including 3 chicks still in one nest. In order to examine survival, movements and behavior of parrot chicks during their post-fledging months, all 8 (5m:3f) of the wild chicks were fitted with radio transmitters and individually numbered metal leg bands.

Of the two chicks radioed from the West Fork (WF) nest, one chick was apparently killed by an avian predator about 5 days after leaving the nest and the second chick was moving with a flock of 5-6 parrots for about a month before the transmitter collar was found. Apparently, the attachment thread had been severed.

The 3 radioed chicks fledged normally from SF#1 nest at the end of June. One radio signal was lost in July with the fate of the chick unknown. The 2 remaining chicks stayed in the South Fork area until the end of September when both left the valley. One chick returned a week later with a weak signal - it was not heard again. The second chick was located in an inaccessible area of the Forest while searching for the radios with an airplane. Shortly after that the signal stopped moving, the parrot remains were found but because the carcass was several days old we were unable to determine the cause of mortality.

The 3 chicks from SF#2 nest roosted and foraged primarily in South Fork along with the SF#1 chicks through July. By the end of July the SF#2 chicks had left the valley with an adult flock to forage. During September they generally alternated their movements between South Fork and East Fork/West Fork/Caimitillo Valleys on the other side of El Yunque. However, several times the chicks could not be located in traditional valleys, suggesting movements to unknown areas of the Luquillo Forest. One radio signal was lost mid-September with the fate of the chick unknown. In early October the 2 remaining chicks separated from the adult flock and roosted in a separate valley. One chick rejoined an adult flock in late October. The other chick stayed in Caimitillo by itself until November 10, when the signal indicated that the bird was not moving. Remains of this chick suggested hawk predation. The signal from the other chick's transmitter was lost in November.

By the end of November, when the field portion of the radio telemetry study was finished, 3 parrots had been recovered dead (transmitter, bones and feathers were found), 1 radio was found with no indication of the parrot's fate, and 4 of the radios stopped functioning.

Captive Flock

In 1987, four pairs of captive Puerto Rican parrots (double over previous years) produced fertile eggs. Of the total of 23 eggs laid (two of the pairs were double clutched), 13 were fertile (Table 2). Four chicks hatched and fledged (Table 2). Females from 4 additional pairs laid 14 infertile eggs. The 3 females that successfully recycled after their first clutch was pulled,

Table 2. Production of captive Puerto Rican and Hispaniolan parrots, Luquillo Aviary, 1987.

Species	No. fertile pairs	No. eggs	No. fertile eggs	No. eggs hatched	No. chicks fledged
Puerto Rican	4	23	13	4	4
Hispaniolan	4	23	20	13*	12

* three of the 23 eggs were laid very late and incubation was terminated before hatching.

laid an average of 7 eggs in later clutches. The addition of 5 chicks (1 produced from a wild egg and 4 produced in captivity) increased the captive Puerto Rican parrot population to a total of 41 birds: 4 breeding pairs (4m:4f); 15 nonbreeding parrots of reproductive age (4m:11f); and 18 at pre-breeding age (13m:5f). Two of the SF#1 chicks developed growth retardation problems; despite intensive veterinarian care both chicks died.

Four fertile Hispaniolan parrot (*Amazona ventralis*) pairs produced 12 fledglings (Table 2). This production raised the number of surrogate species in the Luquillo Aviary to 60 (33m:23f:4 unknown). Currently, 7 Puerto Rican and 22 Hispaniolan parrots are being held for the Río Abajo Aviary (Department of Natural Resources) in accordance with the Memorandum of Understanding between the Puerto Rico Department of Natural Resources and U.S. Fish and Wildlife Service (USFWS).

In the past, the majority of the captive adult female Puerto Rican parrots have laid infertile eggs due to the lack of males for pairing or due to the ineffectiveness of mates. Artificial insemination is a viable means to increase production and genetic variation within flock. Research on artificial insemination techniques yielded a fertile Hispaniolan egg in 1987. This was considered a major breakthrough in the captive breeding program of the Research Station. Apparently, good quality semen can only be obtained from paired males; however collection of semen seemed to delay natural breeding. Because 1987 data was based on a small sample size, next year a more rigorous experiment will be conducted.

To rule out the possibility of inadequate nutrition as an impediment to captive breeding for the Puerto Rican parrot, a study was conducted in collaboration with Avi-Sci Inc., to determine the nutritional requirement of the captive flock. Hispaniolan parrots were placed on four treatment diets. Feed consumption was monitored daily and body weights plus excrements were collected at 3 month intervals. The experiment ran through December of 1987. A final report is expected in 1988.

The aviary was substantially improved in 1987. The former Hispaniolan aviary and flight cage were dismantled and removed. Forty-four new "Noegel" cages (4'W X 6'L X 4'H) were installed over a cement pad. Two flight cages were constructed near La Mina house for subadults and juvenile parrots. A chicken house was added for the bantam chicken hens. The hens will act as surrogate incubators. The renovation was completed in late December.

The Parrots of Luquillo: Natural History and Conservation of the Puerto Rican Parrot" was published in 1987 by the Western Foundation of Vertebrate Zoology, Los Angeles, California. The authors are Noel Snyder, James Wiley, and Cameron Kepler: the first three project leaders for the parrot program. The monograph is a comprehensive compilation of the research and management efforts which have taken place since the initiation of the Puerto Rican Parrot Conservation Program.

Acknowledgements

The parrot project is an interagency cooperative effort. The authors would like to acknowledge the hard work of Carlos Laboy (PRDNR); Marc Bosch, Víctor Cuevas, Orlando Carrasquillo (Caribbean National Forest); Giovani Cabán, Oscar Díaz, and Orland Rivera (Institute of Tropical Forestry); and Fernando Nuñez, Hernán Abreu, Betsy Anderson, Tyrone Medina, Irving Ortiz, Maureen Rowe, Monica Tomosy, and Edgar Vázquez (USFWS).

PUERTO RICAN PARROT NEST CONDITIONS AND USE, 1987 AND MANAGED NEST USE 1968-1987 CARIBBEAN NATIONAL FOREST

Marc Bosch
Wildlife Biologist

In 1987 there were 45 Puerto Rican Parrot Project-provided nest structures available to the wild parrot (*Amazona vittata*) population within the Caribbean National Forest. Thirty-two of the nests were polyvinyl chloride (PVC) artificial nests, and thirteen were improved natural nests. All nests are in three traditional parrot nesting areas - West Fork, East Fork, and South Fork. The improved natural nests are in hollow colorado trees (*Cyrilla racemiflora*), and like the PVC nests, they have been weather-proofed and otherwise improved to provide optimum parrot nesting structures regarding size, appearance, perches, interior, etc.

In 1987 three of these nests were used by breeding parrots. Two were artificial nests and one was an improved natural nest. Only two of these nests were eventually successful, and five birds fledged from the two nests. In addition, a new parrot pair nested in a natural colorado tree cavity, and successfully fledged three chicks (Tables 1 and 2; Fig. 1). See also Table 1 in section, Puerto Rican Parrot Cooperative Research, by Marcia H. Wilson et al. of U.S. Fish and Wildlife and Jan Kalina and Wayne J. Arendt of Institute of Tropical Forestry, U.S. Forest Service.

Of the 45 project-provided nests available in 1987, three were used by parrots, and 23 remained unused. During the year 13 nests were used at some time by pearly-eyed thrashers (*Margarops fuscatus), eight* were used by honeybees (*Apis mellifera*), and one was used by black rats (*Rattus rattus).* Competitor occupancy of nests generally occurred after the January-February period when parrots select nest sites, and probably had little if any effect on nest selection by parrots. All nests were closed at the end of the breeding season, in July and August, to prevent nest use by competitors during the non-breeding season.

After the breeding season major repairs were done on the West Fork active nest. Since the tree on which this PVC nest was mounted is about to die and fall, the nest was moved to a metal pole which was installed so as to maintain the nest in the exact same location. At the same time the nest was better weatherproofed and a new entrance vine added.

Major improvements were made to the new, natural nest in the South Fork area. The nest was weatherproofed, a bottom screen, nesting material, rain

Table 1. Chronology of 1987 breeding season, Puerto Rican Parrot wild population, Caribbean National Forest

February	8 adult parrot pairs observed
February	4 nesting (breeding) pairs
February-March	14 eggs laid in the 4 nests
March-April	9 chicks hatched from 3 nests (4 eggs died from late embryonic death, 1 died at hatching)
May-June	8 chicks fledged (1 chick of a 4 chick clutch was not being fed; chick brought to Aviary

Table 2. Results of 1981-1987 breeding seasons, Puerto Rican Parrot wild population, Caribbean National Forest.

Year	Breeding pairs (Active nests)	Eggs laid	Chicks hatched	Chicks fledged*	Number of nests producing fledglings
81	4	12	9	10	3
82	4	11	5	8	4
83	4	9	5	6	3
84	4	6	3	4	3
85	4	8	7	12	4
86	3	8	7	4	2
87	4	14	9	8	3

* some chicks fledged from wild nests were fostered into the nests from the captive flock.

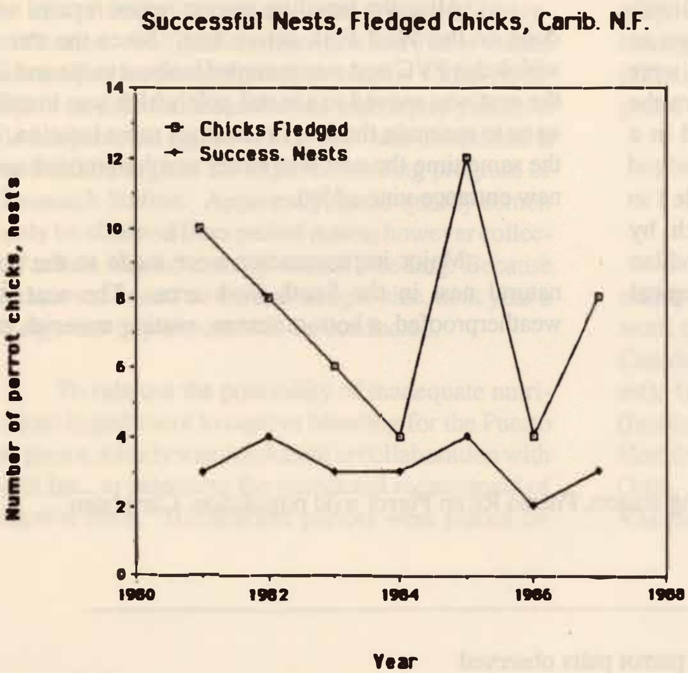

Figure 1. Number of successful Puerto Rican parrot nests, and number of chicks fledged, 1981-1987, Caribbean National Forest wild parrot population. Some chicks fledged from wild nests were fostered into nests from the captive flock.

deflector and entrance vine added, and an inspection door built at the bottom of the nest. All other nests were also maintained after the breeding season. Entrance vines, rain deflector, bottom screen, doors/hinges, and tree climbing spikes were the most common maintenance needs. During 1987, two trees which supported PVC artificial nests fell. Neither of the nests had ever been used by parrots, and one has had a major honeybee hive in it for several years. These nests will be removed and repaired for possible future use.

There are currently 44 project-provided nests available for breeding parrots in 1988. Thirty are PVC artificial nests, and 14 are improved natural nests in colorado trees. Eight are in West Fork, 23 are in East Fork and 13 are in the South Fork nesting area. All have been repaired, opened for use, and provided with dry nesting material. Given the demographics of the parrot population and the number of parrot pair bonds that were established in 1987 (eight), there is excellent potential for more pairs breeding parrots in 1988 than the four which occurred in 1987.

The wild Puerto Rican parrot population has continued to increase since 1975, when it numbered 13 birds (Table 3 and Fig. 2). In late 1987 there were about 35 parrots in the flock.

During the past 20 years ten of the currently managed nests have actually been used for breeding (to at least egg stage) by parrots (Fig. 3). From 1968 to 1974 only one managed nest was used for breeding in any given year. Since 1975 from three to five different managed nests have been used for breeding each year. Of the 10 nests used by parrots, seven are improved natural

Table 3. Representative minimum counts of Puerto Rican Parrots, Caribbean National Forest.

Year	Wild population	Captive population	Total
1954	200	-	200
1963	130	3	133
1966	70	3	73
1968	24	3	27
1971	16*	3	19*
1975	13*	14	27*
1980	19	15	34
1982	29	17	46
1985	35-37*	29	66*
1986	31	37	68
June 1987	41	42	83
October 1987	at least 35	41	76

* by reasonable inference.

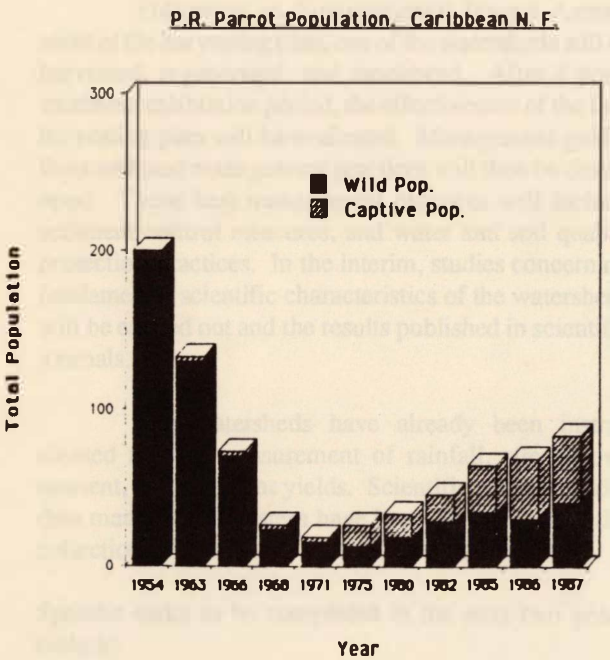

Figure 2. Puerto Rican parrot wild and captive population trends, 1954, 1987, Caribbean National Forest.

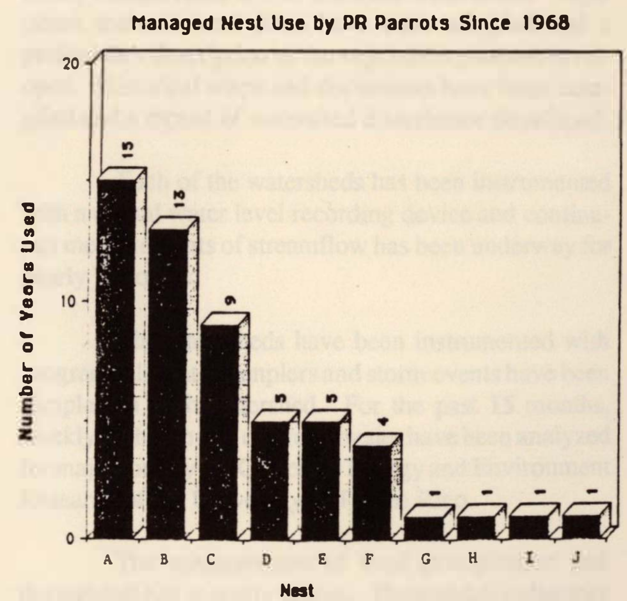

Figure 3. Managed nest use by Puerto Rican parrots since 1968 in the Caribbean National Forest, December, 1987.

nests in colorado trees, and three are PVC structures. Of the 65 nesting attempts in the 10 nests (10 times a nest was used to produce a second clutch in a given year) since 1968, 34 have been in PVC nests, and 31 have been in either natural or improved natural nests. During the 20 year period, parrots using the 10 nests have produced at least 195 eggs, and 97 chicks have fledged into the wild from these nests (Fig. 4).

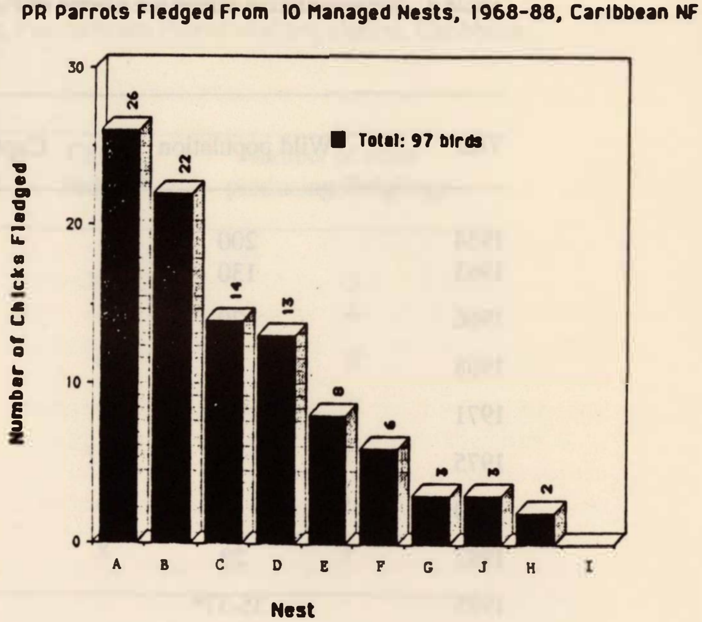

Figure 4. Number of Puerto Rican parrot chicks that have fledged from the ten managed nests that have reached egg stage, Caribbean National forest, 1968-1988.

UPDATE ON THE WATERSHED MANAGEMENT PROJECT

Frederick N. Scatena
Hydrologist

The Institute of Tropical Forestry has recently begun detailed studies on three forested watersheds in the Luquillo Mountains of Puerto Rico. These 6 to 10 hectare watersheds will become the center of active, long term, scientific research concerning timber and ecosystem management in humid tropical forests. Research results will be used to develop best management practices for the protection and utilization of these ecosystems.

In the first and present phase of the project, the hydrologic, geomorphic, and botanical characteristics of the watersheds are being defined. Scientific investigations have be initiated and base line data is being collected. Following this initial calibration period, which is expected to last at least two years, the Institute will sponsor a workshop to evaluate state-of-the-art timber management practices and devise a harvesting plan for one of the watersheds. The goal of this plan is to determine the most effective method of timber management given the existing environmental, economic, and social constraints.

Following an Environmental Impact Assessment of the harvesting plan, one of the watersheds will be harvested, regenerated, and monitored. After a post-treatment calibration period, the effectiveness of the first harvesting plan will be evaluated. Management guidelines and best management practices will then be developed. These best management practices will include sediment control measures, and water and soil quality protection practices. In the interim, studies concerning fundamental scientific characteristics of the watersheds will be carried out and the results published in scientific journals.

The watersheds have already been instrumented for the measurement of rainfall, streamflow, nutrient, and sediment yields. Scientific protocol and a data management system have been developed and the collection of continuous baseline data has begun.

Specific tasks to be completed in the next two years include:

Calculation of hydrologic budgets for the watersheds. This data base will include rainfall-runoff relationships, streamflow, and precipitation frequencies.

Determining the average annual sediment yield from the basins and assessing the relative importance of various sediment sources and deposition sites.

Determining the annual import of nutrients from precipitation and the annual export in streamflow.

Determining which techniques and methodologies are best suited for watershed studies in the humid tropics.

Accomplishments that have already been made include:

The drafting of 1:500 scale topographic and geomorphic maps of the watersheds. Detailed 1 meter contour interval topographic maps have been completed for approximately 75% of the study area. Geomorphic maps of major landforms, soils, and fluvial features are nearly complete for two of the three watersheds. Vegetation transects and plots have been sampled and a preliminary description of the vegetation patterns developed. Historical maps and documents have been complied and a record of watershed disturbance developed.

Each of the watersheds has been instrumented with a digital water level recording device and continuous measurements of streamflow has been underway for nearly 3 months.

The watersheds have been instrumented with programable water samplers and storm events have been sampled in each watershed. For the past 15 months, weekly grab samples of stream water have been analyzed for major ions by the Center for Energy and Environment Research of the University of Puerto Rico.

The measurement of total precipitation and throughfall has recently begun. Throughfall collectors have been placed in the watersheds and weekly and storm

totals are being collected. A tree-top walk-up tower has just been ordered and will be operational by the end of the calendar year (1987). This tower will support a climatic station that will be installed following the specifications of the National Science Foundation. In the meantime, total weekly precipitation is being measured by bulk collectors in and near the watersheds.

The export of bedload sediment in each watershed is being determined from the weekly accumulation of sediment behind the stream weirs.

Litter traps have been placed across the stream channels and the total weekly export of plant litter is being determined for each watershed. In addition, a variety of litter traps have been placed in the watersheds to test the efficiency of various trapping techniques.

Preliminary assessments of the aquatic habitat and the avian populations of the watersheds have begun. Stream macro-fauna were sampled for several weeks during the summer of 1987 and a study of organic detritus has been initiated. Avian specialists from the Institute's Wildlife Research Program have made a reconnaissance survey of the watersheds and are developing plans for future studies.

A graduate student from Rutgers University is investigating the relationship between substrates and tree survival in the watersheds.

The watersheds have already been visited by scientistis from Nepal, Burma, England, Venezuela, Puerto Rico, and the United States.

ACTIVITIES OF THE REGIONAL FORESTRY ADVISOR

Loren B. Ford, Ph.D.
Caribbean National Forest

The Regional Forestry Advisor/Caribbean (Loren Ford) is a member of the Caribbean National Forest staff, assigned to provide and coordinate forestry technical assistance to USAID missions of the Caribbean, and to coordinate the US Forest Service Program for Tropical Forestry in Latin America and the Caribbean. A major reason for stationing this advisor in Puerto Rico is to integrate international forestry activities with the Institute of Tropical Forestry, by seeking opportunities for transfer of research results to other countries of the Caribbean Basin, and by identifying international forestry research needs for consideration as part of the Institute's research portofolio.

About 50% of the advisor's time has been spent traveling, in response to USAID mission technical assistance needs and related work (Table 1). Travel and results during FY87 are listed below. Other activities have included co-editing the proceedings of the Third Meeting of Caribbean Foresters held 19-23 May 1986 in Guadeloupe, French West Indies (see list of Institute publications for reference) and initiating a newsletter for the Caribbean Chapter of the International Society of Caribbean Foresters, the *Hogplum Gazette*.

Table 1. Completed activities of Regional Forestry Advisor/Caribbean during FY87

Destination	Duration	Activity
Jamaica	2 weeks October	Draft technical analysis for USAID/Kingston Hillside Agriculture Project. Explore possibilities for participation of Jamaica Forestry and Soil Conservation Division.
Madison, Wisconsin	1 week October	Participate in Tropical Forestry working group at FS Forest Products Lab annual meeting, with Dr. Ariel E. Lugo.
Moscow, Idaho	1 week October	Evaluate eight-week training in forest management for 10 Honduran foresters given by University of Idaho College of Forestry, Wildlife and Range Sciences.
Molokai, Hawaii	1 week November	Present two talks at workshop on Biological and Genetic Control of the *Leucaena* Psyllid, sponsored by the USAID F/FRED Project and Nitrogen Fixing Tree Association.
Haiti	1 week Jan.-Feb.	Review proposals for the research and tree improvement components of the USAID/Haiti Agroforestry Outreach Project.
Belize	1 week	Assess possibilities of USAID Forestry Programming. Review Belize forestry and natural resources issues Prepare concept paper for USAID Forestry Project.

Table 1. (cont'd)

Destination	Duration	Activity
Mexico	2 weeks May	Assist Dr. Frank H. Wadsworth, Dr. Paul Van Deusen, and Mexican colleagues with a 10-day workshop on secondary forest management for Mexican forestry technicians in Chetumal, Quintana Roo.
Costa Rica	4 weeks June-July	Design and negotiate English-language Agroforestry Course for Pacific and Caribbean Island Foresters at CATIE with FS personnel Kathryn Hunter, WO Forestry Support Program, and Len Newell, Pacific Islands Forester. Give presentation at workshop *Gliricidia sepium*: Management and Improvement. Design strategy for dealing with insect and disease problems for USAID/CATIE Tree Crop Production Project.
Jamaica	2 weeks July	Assist Jamaican Forestry and Soil Conservation Division in designing a proposal for participation in USAID Hillside Agriculture Project. Draft annex for USAID FY 88-89 Action Plan analyzing needs and USAID participation for conserving Jamaica's tropical forests and biological diversity.
Belize	10 days August	Draft FY 88-89 Action Plan annex, analyzing tropical forest and biological diversity conservation needs for USAID, with Dr. Mark Shaffer of the USDA Fish and Wildlife Service. Continue planning with Dr. F. William Burley, World Resources Institute, for a Forestry Sector Review for Belize.
Barbados/St. Vincent	1 week August	Assess erosion and social problems of the multi-donor Cumberland River Hydroelectric Project, and implementation of the Cumberland River Watershed Management component, with Kathryn Hunter and CIDA consultant Dr. Wilson Eedy. Discuss implementation with USAID.

Versión en Español

INVESTIGACIONES EN PLANTACIONES

John K. Francis
Dasónomo

Desde la última mitad de este siglo se ha venido estableciendo en Puerto Rico un gran número de plantaciones de adaptabilidad y de producción de especies exóticas y nativas. Algunas de las especies tratadas han fallado o han crecido lentamente, pero otras se han desarrollado impresionantemente. El año pasado informé sobre el desarrollo de varias coníferas tropicales del género *Araucaria* y de caoba africana (*Khaya* spp.). En este artículo se resume el estado de conocimiento de cinco (5) especies para las cuales se terminó el trabajo durante este año.

El *Enterolobium cyclocarpum* o guanacaste es nativa de América Central y el norte de Sur América, pero ha sido plantada por muchos años en Puerto Rico como un arbol de sombra. Probablemente el árbol más grande de guanacaste en Puerto Rico se encuentra en Mayagüez y mide 39 m de alto y 2.4 m de diámetro. Aunque los árboles que crecen aislados tienen troncos de 2 m de largo, en rodales cerrados, los troncos pueden llegar a 10 m o más. La especie reproduce fácilmente y esta adaptada al clima local y a todos los suelos, excepto los mojados. La madera de corazón (heart wood) es de color marrón y resiste el comején y la descomposición.

El *Maesospis eminii*, cuyo nombre común es musizi, es nativo del Africa ecuatorial. En la zona urbana, esta especie es un colonizador de rápido crecimiento y las semillas son dispersadas por los animales y los pájaros. En Puerto Rico los árboles de las plantaciones originales (1962) están dando frutos y las semillas se han dispersado a cientos de metros de los árboles madre. Todo indica que esta especie se limitará a los bosques secundarios en las partes húmedas de la isla. Se adapta a casi todos los terrenos fértiles pero no así a los mojados. Musizi tiene buena forma y además poda muy bien. Es capaz de producir tallos de 0.5 m de espesor en 20 a 25 años. La madera es color marrón claro, de densidad mediana, se puede labrar fácilmente y es útil para producir papel y otros productos provechosos. La madera musizi no es resistente al comején ni a la descomposición.

El *Terminalia ivorensis* ó idigbo es un árbol muy bonito y majestuoso, oriundo del Africa ecuatorial. Este se poda solo y tiene una forma excepcional. En Puerto Rico se han dado bien en dos plantaciones, los dominantes ganando 1 m de altura y cerca de 2 cm de diámetro por año. Arboles en ambas plantaciones se han reproducido, aunque la semilla no ha viajado lejos del árbol madre. La especie se ha adaptado extensivamente a la parte húmeda de la isla. La madera del idigbo es amarilla lustrosa y de gran valor en el comercio internacional. Esta no es resistente a la descomposición aunque resiste un poco el comején.

Hernandia sonora, conocido localmente como el mago, es nativa de Puerto Rico, así como de otras comarcas que bordean el Caribe. Se ha plantado con éxito en varios lugares de la isla. Se establece fácilmente y crece con troncos largos y claros. En toda clase de terreno en que se ha plantado la especie crece lentamente, requiriendo por lo menos 1250 mm de precipitación anual en las lomas. El mejor crecimiento del mago ocurre adyacente a cursos de agua en las montañas de Luquillo, donde existen unos árboles que llegan a 40 m de alto y exceden 1 m de diámetro. La densidad de la madera es moderadamente baja en gravedad específica y no es actualmente comerciable. Puede ser utilizada, quizás, en tableros de partículas ("flake board") o productos similares.

Hibiscus elatus, comunmente llamado mahoe, es nativo de Jamaica y de Cuba. Se ha plantado extensamente en los bosques húmedos de la isla, generalmente con un éxito espectacular. El mahoe se adapta a todos los suelos de áreas húmedas de Puerto Rico y además se reproduce agresivamente. Su crecimiento es rápido. En algunos lugares los dominantes alcanzan en 20 años 28 m de altura y si se le ofrece sitio suficiente para crecer podrían en 25 años alcanzar alrededor de 40 cm de diámetro. El tronco poda bien, pero a veces contiene muchas ramas epicórmicas. El mahoe puede mantener de 40 a 70 m^2/ha de área basimétrica y producir de 10 a 25 m^3/ha de madera por año. La madera es fácil de trabajar y tiene un variado campo de usos.

El estudio de las plantaciones continua y ahora se concentra en las especies *Fraxinus uhdei*, *Pterocarpus macrocarpus*, *Tectona grandis* y los eucaliptos.

ESTUDIOS COOPERATIVOS EN EL MANEJO DE LAS PLANTACIONES DE PINO EN EL CARIBE

Leon H. Liegel
Científico de Suelos

Está por terminarse el trabajo comenzado en el 1983 bajo los auspicios del US-AID para el *Pinus caribaea* (veáse cartas anuales anteriores). Entre los países que han cooperado en este trabajo se incluye Costa Rica, Jamaica, Puerto Rico, Trinidad y Venezuela.

Los datos obtenidos en 160 parcelas experimentales fueron analizados en cooperación con personal biométrico de nuestro Instituto de Estudios Cuantitativos en New Orleans, Louisiana. Se prepararon varios modelos de crecimiento para pronosticar el rendimiento total del rodal (sobre la corteza, m^3/ha), el índice de sitio estimado para una edad básica de 15 años y el número de árboles que sobreviven por hectáreas a diferentes edades.

Información suplementaria mostró que en muchos casos el pobre crecimiento fue causado por falta de manejo y no por condiciones edáficas/geológicas (e.g., plántulas de baja calidad, problemas de plantío y falta de tratamientos silvícolas). En general, las diferencias de rendimiento no fueron significativas en ningún país al ser analizadas en base a suelos, formación geológica y zona de vida.

Más de la mitad del presupuesto para el estudio ($150,000) se utilizó fuera de Puerto Rico en adiestramientos y actividades de desarrollo de las instituciones dasonómicas. Específicamente, 23 personas fueron enviadas a 12 cursos que fluctuaban entre una semana a seis meses de duración.

TRABAJO COOPERATIVO CON LA UNIVERSIDAD DE YALE

John A. Parrotta
Centro de Estudios Energéticos y Ambientales
Universidad de Puerto Rico

El manejo intensivo de plantaciones de biomasa para la energía de árboles de rápido crecimiento a veces envuelven exportación substancial de nutrientes relacionados con el método de corte. A un largo término, esta pérdida puede resultar en una mengua de productividad debido a limitaciones de nutrientes, particularmente en lugares marginales comúnmente señalados en plantaciones de varios países tropicales. El proyecto de Toa Baja "Bio-Energy Plantation" se inició en 1984 con el propósito de evaluar la influencia del espaciamiento inicial y edad de la plantación, la producción, la toma y el almacenamiento de los nutrientes en las plantaciones forestales de alta densidad en Puerto Rico (Parrotta 1987a).

Albizia lebbek, la especie tomada para el estudio, es una especie fijadora de nitrógeno, semi-caducifolia y adaptada a una gran variedad de suelos. La especie crece en una variedad de ambientes tropicales y subtropicales semi-áridos y húmedos y es popular para la reforestación en todo el mundo (Parrotta 1987b). El plantío para este experimento consistió de plántulas obtenidas de semillas de 4 meses de edad de *Albizia lebbek*. Las semillas fueron coleccionadas cerca de Ponce, Puerto Rico, de un único árbol padre. Las parcelas preparadas se establecieron en noviembre de 1984 a una densidad de 2,500; 10,000 y 40,000 árboles/ha. El lugar de la plantación, localizada aproximadamente a 10 km al oeste de San Juan, se caracteriza por suelos calcáreos profundos, de buen drenaje, moderadamente alkalinos (pH 7.9 a 8.4), pobres en materia orgánica y varios nutrientes (Parrotta 1987a).

El grado de crecimiento individual del árbol, las características de desarrollo, la producción total de biomasa, la partición de esta y los patrones de fijación de los nutrientes fueron evaluados para cada tratamiento de densidad durante los primeros tres años del desarrollo de la plantación. Los resultados para los primeros 36 meses están resumidos en las Tablas 1 y 2 (páginas 3-5), los resultados anteriores fueron presentados y discutidos en otras publicaciones (Parrotta 1987a, c).

A los 36 meses, el tamaño promedio del árbol era de 4.4, 3.7 y 2.4 m y el promedio del diámetro del tallo basimétrico era de 7.5, 4.9 y 2.6 cm, respectivamente en un tratamiento de densidad bajo, intermedio y alto. El correspondiente promedio de biomasa aérea a los tres años era de 8.69, 2.98 y 0.48 kg. A los tres años la biomasa aérea estimada era de 21.7, 29.5 y 18.7 Mg/ha (peso secado en estufa) en un tratamiento de densidad baja, intermedia y alta, respectivamente (Tabla 1, página 3). El total del contenido de nutrientes por unidad de la biomasa aérea (para N, P, K, Ca y Mg) fue substancialmente más alto en los tratamientos de densidad de los que pudieran ser justificables por diferencias en producción (Tabla 2, página 5). Las diferencias entre los tratamientos de densidad en unidades de costo de nutrientes (Kg nutriente por unidad de producción de biomasa) estaban entrelazadas a dife-rencias de tratamiento en la morfología del árbol y en el tejido de la proporción de la hoja rica en nutrientes, la rama y la corteza que comprenden el biomasa sobre la tierra.

Los resultados de este estudio sugieren que una combinación de densidades bajas de las plantaciones, un tiempo de rotación más extenso y las prácticas de cosecha menos intensivas pueden resultar en la producción incrementada de biomasa y en unidades de costo de nutrientes decrecida.

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INVESTIGACION EN BOSQUES NATURALES

Peter L. Weaver
Dasónomo

Bosques Secundarios

En el 1980 se llevó a cabo en Puerto Rico un inventario de los recursos forestales secundarios. En 1985 se utilizó una sub-muestra de las parcelas permanentes originales con el propósito de determinar los cambios en el área de bosques (Birdsey y Weaver 1987). El área total de bosques en Puerto Rico aumentó de 279,000 ha en 1980 a 300,000 ha en 1985. La mayor parte de los bosques nuevos crecían en pastos abandonados. Los bosques secundarios y las parcelas abandonadas de sombra para café fueron los responsables del 76% de toda la tierra de bosque. Bosques secos y parcelas activas de sombra para café se responsabilizan para el 11 y 10%, respectivamente, de toda la tierra de bosque.

La materia orgánica del suelo y la hojarasca suelta fueron también estudiadas de acuerdo a la zona de vida (clima), tipo de cubierta de bosque, grupo de suelo y topografía (Weaver et al. 1987). El contenido de la materia orgánica en los primeros 23 cm del suelo era mayor en el bosque húmedo que en el bosque muy húmedo. Se encontraron, además, cantidades más grandes de materia orgánica en los bosques con altos volúmenes de madera, una tendencia que fue menos pronunciada en el bosque muy húmedo. Se determinaron también interacciones significativas para materia orgánica entre los grupos de suelos (volcánico profundo, volcánico poco profundo, arenoso y de piedra caliza) y entre las distintas clases de bosques (secundario joven, secundario mayor, sombra para café abandonada y de sombra activa de café). Por otra parte, diferencias grandemente significativas en niveles de materia orgánica fueron observadas por la forma del terreno y el declive en las áreas de sombra activa del café en los bosques muy húmedos. Los valores más bajos se encontraron en los terrenos de forma convexa y en terrenos con pendientes mayores de un 45%. Almacenamiento de hojarasca suelta en bosques húmedos y muy húmedos no fue significativamente diferente, ni hubo una interacción significativa con zona de vida. Sin embargo, se detectaron diferencias significativas por categoría de volumen maderero, grupos de suelo y clases de bosques. Dentro de estos bosques alterados, tanto el húmedo como el muy húmedo, volúmenes grandes de madera tienden a ser asociados con grandes cantidades de hojarasca suelta.

Son de vital interés las oportunidades de ordenación para los bosques secundarios porque estos están aumentando rápidamente. El inventario de bosques del 1980 en Puerto Rico demuestra que cerca de 60,000 ha de sombra para café cubren las montañas del interior. Dentro de éstas, 34 especies de árboles madereros fueron identificadas. Los bosques de sombra para café pueden ser ordenados en varias maneras, dependiendo del propósito del agricultor y la composición de las especies en la sombra para café. Entre las oportunidades tenemos agroforestería, plantaciones de taungya (cosechas intercaladas con árboles madereros), entresacas, enriquecimiento o el establecimiento de plantaciones cerradas. Se desarrolló una gráfica de ordenaciones alternativas enfatizando la producción de madera y agroforestería (Weaver y Birdsey 1986). También se discutieron alternativas para el manejo de bosques secundarios para los productos de madera (Weaver 1986a).

Otras alternativas para el manejo de bosques secundarios incluyen plantaciones de enriquecimiento (plantaciones en línea, limba, en cabollán mafuku, siembras Anderson, plantaciones en aperturas, plantaciones bajo cobertura parcial y otras técnicas). Se han usado en una base experimental por los menos 163 especies de árboles en por lo menos 12 países neotropicales para enriquecer los bosques (Weaver 1986b). En tres países se han desarrollado estas plantaciones en una escala de producción. Algunas 25 especies se probaron adecuadas para ser plantadas por medio de enriquecimiento. Desafortunadamente, las plantaciones de enriquecimiento tienen una reputación pobre por las prácticas malas de establecimiento y mantenimiento. Se pueden adelantar en favor de la técnica de enriquecimiento argumentos biológicos, económicos y ambientales. De todos los diferentes métodos usados, el de la plantación es el que aparenta ser mejor.

Bosque de Luquillo

El *Cyrilla racemiflora* L. (cyrilla, cyrilla de pantano o titi) naturalmente ocurre desde Virginia (en los Estados Unidos) a través de las Antillas hasta el norte de Brazil. De acuerdo a su extensión, cyrilla es un árbol pequeño pero, en las montañas de las Antillas, ocasionalmente alcanza un diámetro de 2.5 m o más.

La existencia de data relacionada con el crecimiento de cyrilla hizo posible la investigación de la ecología en varios sitios del Bosque de Luquillo. El uso de técnicas aritméticas para estimar la edad del árbol demostró que un árbol de 1 m en diámetro tenía 660 años (Weaver 986). Por otra parte, árboles excepcionalmente grandes aparecían ser el producto de fundición de tallos próximos. Finalmente, la regeneración del cyrilla fue correlacionada con disturbios pasados en el Bosque de Luquillo. Un número desproporcionado de árboles estaban en la clase de 30 a 40 cm, la cual se originó después de que tres huracanes azotaron a Puerto Rico entre el 1772 y 1776.

La estructura y la dinámica en el bosque de palo colorado (bosques húmedos y muy húmedos, *sensu* Holdridge) de las montañas de Luquillo fueron descritas en tres capítulos de una disertación (Weaver 1987). La primera atañe a cambios en la estructura y el crecimiento del bosque después del huracán. La segunda se refiere a la estructura y composición del bosque colorado relativo a los gradientes ambientales. El último capítulo era mayormente sobre la productividad del bosque. Los cambios en la estructura y el crecimiento después de los huracanes se resumieron en la Carta Anual del año pasado (Weaver 1986d, e, f). Descripciones más detalladas de las relaciones entre especies y los sitios donde se encuentran, así como la productividad, se presentarán en Cartas Anuales subsiguientes cuando se publiquen los manuscritos individualmente.

Islas de St.John y Hassel, Islas Vírgenes, Estados Unidos

La isla de St. John, una de las tres mayores de Islas Vírgenes, tiene un tamaño de 5,180 ha y la isla Hassel, localizada en el puerto de Charlotte Amalie, es de 55 ha en tamaño. Tres cuartas partes de St. John y virtualmente toda la isla Hassel están bajo la jurisdicción del Servicio de Parques de los Estados Unidos.

Una encuesta sobre la isla, utilizando la terminología Beard con alguna modificación, reportó 10 tipos de vegetación: mangle y áreas adyacentes, tres bosque húmedos (tierra adentro, galería y la cuenca), cuatro bosques secos (siempre-verdes, chaparral, cactus con espinas y vallas costeras), vegetación secundaria y pastos (Woodbury y Weaver 1987). Todas las especies fueron clasificadas de acuerdo al tipo de bosque y a las formas de vida (árbol, arbusto, bejuco, herbáceas, epífita). Se indicaron las abundancias relativas de todas las especies (raras, ocasionadas, frecuentes, comunes) por los tipos de bosques. Se encontraron 18 especies raras y estas fueron localizadas en mapas. Seis de éstas especies pueden ser nuevas a la ciencia.

Un texto breve proporcionó data ambiental para las islas, algunas preocupaciones ambientales y recomendaciones para la ordenación de los terrenos. Se prepararon mapas donde se delineaban todos los tipos de vegetación. Además, se sometió al Servicio de Parques una colección de todas las especies para el herbario.

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OTROS ESTUDIOS EN BOSQUES NATURALES

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Modelos del ciclo de carbono asumen que los bosques maduros están en un estado estable con la atmósfera. Esta hipótesis fue cuestionada (Lugo y Brown 1986). La evidencia sugiere que la vegetación y suelos de sistemas maduros son perturbados frecuentemente (<300 años) y por lo tanto exhiben una absorción neta de carbono de la atmósfera. La consideración crítica en este argumento es el tiempo necesario para llegar al estado estable. Los modelos en uso limitan la consideración a 120 años, un intervalo muy corto e inadecuado para simular realísticamente el ciclo de carbono en la biota.

Se estudió la velocidad de crecimiento a largo plazo de 32 palmas (*Prestoea montana*) utilizando medidas de altura y diámetro tomadas cuatro veces entre el 1946 y 1982 (Lugo y Rivera Battle 1987). Se contaron todas las cicatrices de hoja en el tallo para estimar la tasa de producción de hojas y se midió la distancia entre cicatrices para establecer relaciones entre la producción de hojas y crecimiento en altura. Durante este período de 36 años (Fig. 1, página 8), la altura y el crecimiento en diámetro y la producción de las hojas de estas palmas no fueron constantes. La distancia mayor entre las cicatrices de las hojas fue indicativo del crecimiento rápido en altura, pero no así de la velocidad de producción de la hoja. Las palmas que se convirtieron en dominantes siempre crecieron rápidamente (>120 cm/año) en altura cuando eran pequeñas, pero el crecimiento aminoró cuando llegaron al dosel. Las palmas pequeñas con crecimiento lento en altura se mantuvieron reprimidas y perdieron la capacidad como adultos de crecer rápidamente en altura. El crecimiento en altura disminuyó con la edad de 0.07 cm/año (ES = 0.02) entre 1946 y 1951 a 0.01 cm/año (ES = 0.003) entre 1951-82. La producción de hojas tuvo variaciones significativas durante distintos intervalos de tiempo. El promedio de producción fue 4 hojas/año durante el período de 36 años de estudio, 5.6 hojas/año entre el 1946 y 1951 (p = .001) y 3.8 hojas/año entre el 1951 y 1982. Las palmas que crecieron mas de 5 m de altura desde el 1946 produjeron 4.6 hojas/año y las que crecieron menos de 5 m de altura, e.g., las suprimidas produjeron 3.7 hojas/año. El mejor estimado para el promedio de la edad de todas las palmas fue de 61.1 años (ES = 2.4), obtenida de una velocidad de producción de hojas en una población a largo término (Fig. 2, página 9). En el 1932, cuando un huracán azotó el bosque, las plantitas de semillas o plantas jóvenes eran miembros de la edad dominante.

Una revisión de la literatura sobre los bosques secos tropicales identificaron 18 lugares (caída de lluvia entre 603 a 1800 mm/año) con data ecológica (Murphy y Lugo 1986). Las características estructurales y funcionales de estos bosques se comparaban con aquellos de zonas de vida de bosques lluviosos y húmedos (Tabla 1, página 10). Las plantaciones en ambientes tropicales secos produjeron madera a una velocidad de 4-18 t/ha.año, dependiendo de la especie (Fig. 3, página 11). Estos son valores bajos comparados con plantaciones en ambientes húmedos que producen madera a una velocidad de 10 a 30 t/ha.año. Las zonas de vida tropicales y subtropicales secas son zonas preferidas para la utilización y vivienda humana (Fig. 4, página 12). La figura 5 (página 12) es un diagrama hipotético ilustrando la respuesta de los bosques secos tropicales al impacto humano.

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ESTUDIOS ESPECIALES

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Libro Sobre la Producción Forestal

El manuscrito del libro "Forest Production for Tropical America" (Producción forestal para la América Tropical) se ha editado y está sujeto a una revisión general por dos profesores universitarios con vasta experiencia en dasonomía mundial. Próximamente el manuscrito será sometido a la imprenta del gobierno.

Tendencias en el Crecimiento de Arboles Tropicales

La continuación de análisis del crecimiento de los árboles de la Sierra de Luquillo sobre varias décadas ha producido nueva información sobre los efectos de los factores del microambiente. Unos 1,470 árboles de 14 especies maderables se han usado para estos estudios. El bosque queda entre 200 y 600 m sobre el nivel del mar, sobre suelos ácidos y arcillosos y recibe de 200 hasta 650 cm de lluvia anualmente.

La posición topográfica es un factor que determina la abundancia y la productividad de los árboles en bosques primarios. Un 49% de los árboles se encuentra en las cuestas de las lomas y sólo 11% en los valles. El número de árboles en las crestas es proporcionalmente mayor al área y proporcionalmente menor en los fondos de los valles. Sin embargo, el crecimiento en diámetro de los árboles desde 1958 hasta 1982 fue superior en los valles.

El área basal del bosque que rodea cada arbol es mas alta en los declives más empinados, aún en ellos de mas de 40°. El promedio de la altura total de los árboles de 40 cm dap o más también es mayor en las cuestas de mas de 40°. También el promedio de los diámetros de los árboles en cuestas de más de 40° era superior a los de las cuestas menos empinadas. El declive no tuvo relación con el crecimiento en diámetro desde 1958 hasta 1982.

Las cuestas expuestas hacia el este (los vientos prevalescientes) son más empinadas que las que dan al norte o al este. Habían demasiadas pocas cuestas hacia el sur para permitir conclusiones. El bosque primario en cuestas hacia el este (barlovento) llega a una densidad en área basal mayor que en las cuestas hacia el oeste (sotavento). El aspecto no afecta ni a la altura ni al diámetro promedio de los árboles del bosque primario, pero el crecimiento en diámetro es mayor en las cuestas hacia el norte que hacia el este.

La relación entre el diámetro de las coronas de los árboles y de sus troncos tuvo un promedio de 22:1, pero fue mayor para árboles que no tenían árboles competidores muy cerca. El crecimiento de los troncos de los árboles, tanto en diámetro como en área basal es menor en los bosques más densos (área basal de 26 m^2/ha o más) que en los más claros (área basal de 12 m^2/ha o menor).

Los árboles dominantes aumentaron en área basal de sus troncos 41% más que los codominantes, 73% más que los intermedios y 163% más que los suprimidos.

Se están desarrollando modelos para la predicción de crecimiento futuro de árboles individuales. Una ecuación preliminar con tres variables independientes produce una coeficiente de correlación muy satisfactoria (Tabla 1, página 15). Para predecir crecimiento futuro en dap se usan los logarítmos naturales del dap inicial, el diámetro de la corona y el diámetro de la corona dividido por el dap. En estas pruebas los diámetros de las coronas fueron medidos al final, en vez de al principio del período de crecimiento, de manera que los resultados necesitan revisión cuando posteriormente los datos estén disponibles.

INVESTIGACIONES SOBRE LA VIDA SILVESTRE

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Investigación Relacionada con la Cotorra Puertorriqueña

Estudios Biotelemétricos

El esfuerzo cooperativo tri-agencial de informar sobre la mortalidad, movimientos dispersos y el habitat usado por los juveniles de la cotorra puertorriqueña está en su tercer año. El Servicio Forestal de Estados Unidos, el Servicio de Pesca y Vida Silvestre de Estados Unidos y el Departamento de Recursos Naturales de Puerto Rico, son las agencias participantes en la investigación sobre la cotorra puertorriqueña. En el 1987, ocho pichones de cotorra emplumaron en nidos silvestres. Las ocho cotorras juveniles fueron equipadas con transmisores antes de que dejaran el nido. A pesar del fallo de algunos transmisores y la desaparición ocasional de algunos polluelos marcados, se ha obtenido información valiosa de dispersión, movimientos, uso del habitat y las causas de la mortalidad de las cotorras juveniles. Aunque la desaparición ocasional de los signos del grupo completo de cotorras equipadas con transmisores se debió a interferencia causada por topografía áspera (valles profundos y picos altos de montañas), el período extendido de la pérdida de señales sugiere que la bandada de cotorras pueda estar usando valles remotos fuera de las áreas tradicionales. Esto ha sido un hallazgo alentador. El uso de nuevas áreas para la búsqueda de alimentos y como dormideros, establece la creencia de que en otras áreas de las montañas de Luquillo existan habitats apropiados, que puedan servir como sitios de re-introducción una vez la población silvestre empieze a llegar y a tener la capacidad de las áreas tradicionales. Con el uso de valles adicionales por cotorras no reproductoras, nos llega la esperanza de que eventualmente, la cotorra puertorriqueña buscará y usará los nidos de estas nuevas áreas. Esto ayudará a reducir una fijación de vidas por lugar, desde una perspectiva evolucionaria y por lo tanto, el problema de homogeneidad genética. Desde un punto de vista ecológico, el establecimiento de propágulos en áreas nuevas del bosque aumentará la supervivencia de por lo menos, una porción de la población entera y ayudará a proteger el volumen del gene, si el bosque sufre daño extensivo como resultado de desastres naturales o disturbios antropogénicos.

Ecología del Zorzal Pardo

Tiempo de Procreación 1987

La muerte del último pichón de una postura original de tres huevos (los cuales fueron víctimas del ectoparasitismo diptero) el 26 de julio de 1987, marca el cierre oficial de este estudio que estaba en su noveno año. Este año se compara la data con aquellos de ocho estaciones que están bajo análisis.

Morfología del Zorzal Pardo

Un aspecto de este estudio, es la comparación de la variación del tamaño y del dimorfismo sexual dentro de la población de El Yunque y las poblaciones de zorzal alopátricas del Caribe. Aunque la mayor parte de la data analizada, acompañada de tablas y figuras y discusiones del significado biológico y ecológico de estos resultados se presentarán en una publicación más extensa, varios de los resultados se resumen a continuación.

El peso del cuerpo del zorzal pardos era, a excepción de los de la isla de Santa Lucía, directamente correlativo con el tamaño de la isla ($R = 0.93$, $Y = 0.143 + 0.964X$; Fig. 1, página 16). La longitud de las alas varía de acuerdo a la estación y es influenciada por la muda de plumas primarias al tiempo de la medida. La longitud de las alas varía también con la elevación y el tipo de habitat. La longitud de la cola no esta correlacionada con el tamaño del cuerpo y por lo tanto, no estaba en correlación con el tamaño de la isla. La longitud, profundidad y ancho del pico era mayor en poblaciones de zorzales de bosques húmedos en islas mayores que los de islas pequeñas. Sin embargo, el tamaño del pico anterior de la abertura de la nariz, fue significativamente mayor en poblaciones de zorzales que habitaron los bosques secos en las islas pequeñas.

Se encontraron diferencias significativas, elevacionales y estacionales, en las poblaciones de zorzales alopátricos, dentro y entre las islas. Las medidas en las poblaciones de los zorzales en bosques húmedos de tierra alta tienden a ser mayores que las de tierra baja. En la mayoría de las comparaciones morfológicas de zorzales de tierra alta y tierra baja, resulta que los de tierra alta

miden mayor que los de tierra baja, tanto en la estación húmeda como en la seca. La variación entre los carácteres morfológicos de estación fue mínima en las poblaciones de zorzales en las tierras altas del bosque húmedo de El Yunque, pero fue mas pronunciada en las poblaciones de zorzales de bosques secos en la tierra baja de Guánica y Mona.

Se encontró que el peso corporal varía semajantemente cada hora del día, tanto en las poblaciones de zorzales simpátricas como en las alopátricas. Se compararon dos poblaciones de zorzales en Puerto Rico: del bosque húmedo de tierra alta de El Yunque y de tierra baja del bosque seco de Guánica. El peso corporal fluctuaba semejantemente, no solamente entre individuos del bosque húmedo y bosque séco, pero también entre ambos sexos de la población del bosque húmedo (Fig. 2, página 17). Las tomas de muestras del peso corporal de los zorzales capturados antes de las 0700 fueron pequeños en las dos poblaciones y por lo tanto, los datos no fueron incluídos en la Figura 2 (página 17). Sin embargo, los pocos zorzales capturados antes de las 0700 en El Yunque y Guánica (6 y 9 individuos, respectivamente) pesaban mas (112 y 99 gramos, respectivamente) que los individuos capturados entre las 0700 y 0800, sugiriendo que hay picos en el peso corporal cada 5 horas (06000 - 1100) antes de mediodía y cada cuatro horas (1100-1500) más tarde en el día. Estos resultados apoyan algunos datos mas extensivos, tomados de escondites sobre el forraje del zorzal pardo en el bosque húmedo. Los zorzales en El Yunque forrajean más extensivamente a el alba, justo antes del mediodía y poco antes del atardecer.

Los adultos del zorzal pardo en El Yunque mostraron dimorfismo sexual. Las hembras pesaron más y tuvieron los picos más largos, mientras que los machos tuvieron las alas y colas más largas. La longitud del primario numero nueve y del torso, fue semejante entre los dos sexos. Se mostró un cromodimorfismo sutil entre los sexos adultos. Los machos tendieron a tener más pronunciadas plumas blancas en la cola y las regiones escapulares y un efecto escamoso mas distintivo en las plumas del pecho en un fondo blanco puro. Existieron sus excepciones y el revés se ha observado.

Evaluación de la Vida Silvestre

Se presentaron dos informes de investigación durante este año en una serie de publicaciones (Faaborg y Arendt 1985). El primer informe trata de una instancia de depredación por la boa de Sta. Lucía (*Boa Constrictor Orophias*) en el murciélago *Brachyphylla cavernarum* en un albergue localizado en las "Castries Waterworks Reserve" a lo largo del "Old French Road" cerca de Forestiere, Sta. Lucía (Arendt y Anthony 1986). Aunque se ha informado poco sobre la depredación del murciélago por culebras en los albergues de árboles, el gran número de observaciones sugiere que este comportamiento es común entre las boas tropicales. Todos los murciélagos observados y tratados eran hembras lactantes, por lo tanto, se sugiere que la *Brachyphylla cavernarum* ha evolucionado una estrategia reproductiva a base de harén.

La segunda investigación documenta una instancia de la depredación reptiliana por la iguana (*Iguana iguana*) en los huevos del Garza ganadera (*Bulbucus ibis*), dentro de un bosque de mangle en "Fox's Bay", Montserrat (Arendt 1986). Debido a que las iguanas adultas no fueron observadas dentro de la colonia de las garzas, la iguana depredadora era jópven y los huevos de garza eran dañados, por lo tanto, se sugiereque esta forma de depredación es oportuna, se lleva a cabo por las iguanas jóvenes. Este comportamiento puede ser una forma de depredación sanitaria que se ha evolucionado entre procreadores coloniales, a manera de liberar el exceso y productos desechables del ambiente, que resultan del esfuerzo reproductivo.

Estudios Sobre Comunidades de Aves

Los estudios a largo plazo sobre la dinámica poblacional de aves, continuan en Puerto Rico y en la República Dominicana. Los resultados demuestran que las poblaciones de las especies residentes se mantuvieron a un nivel semajante a los años anteriores. En contraste, en el 1987, las especies y el número total de individuos de aves migratorias de Norte América había bajado considerablemente (Tabla 1, página 19). En nuestra estación anilladora del bosque seco de Guánica, las especies migratorias bajaron un 60% del mínimo de los 12 años anteriores, mientras que el número total de individuos migratorios a un mínimo de ocho individuos, el cual ocurrió en el 1981. Esta es una caída de más de 50% del promedio de 19 individuos, en los 12 años anteriores. En el bosque de mangle de Sánchez en la República Dominicana, el número de especies migratorias bajó 33% del promedio de los últimos dos años, mientras que el número de individuos bajó a un 27% del promedio de los últimos dos años (Tabla 1, página 19). En enero de 1988 se muestrearán, nuevamente en ambas islas, la población migratoria de Norte Américacon el propósito de registrar posibles declinajes en sus invernaderos en ambos lugares donde se marcan.

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PROGRAMA COOPERATIVO DE INVESTIGACION PARA LA RECUPERACION DE LA COTORRA PUERTORRIQUENA

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Introducción

La población silvestre de la cotorra puertorriqueña (*Amazona vittata*), ha aumentado gradualmente de 14 individuos en 1975 a 33 al comienzo de la temporada de reproducción en 1987. El programa de reproducción en cautiverio fue establecido en 1973 para evitar que la cotorra puertorriqueña desaparezca, de ocurrir algún evento catastrófico (ej., un huracán o una epidemia) y como una reserva para el apoyo de la población silvestre. En la actualidad, la población cautiva se compone de 41 individuos. Aunque se ha progresado en algunos aspectos, el esfuerzo reproductivo y la productividad de las cotorras cautivas es baja. En 1987 los esfuerzos de investigación se concentraron en estudiar la supervivencia y los movimientos en polluelos y en tratar de incrementar el éxito reproductivo de las cotorras.

Población Silvestre

Aunque de siete a ocho parejas mostraron comportamiento reproductivo durante la temporada de anidaje en 1987, solamente cuatro parejas produjeron huevos. Una de las parejas que produjo huevos fue una pareja nueva que anidó en "South Fork" (SF#2), en un área que las cotorras no habían utilizado para anidar desde 1973. Las cuatro parejas que anidaron produjeron un total de 21 huevos. El total de huevos incluye los huevos producidos por dos parejas que fueron inducidas a anidar dos veces (Tabla 1, página 20). Todos los huevos producidos por las parejas silvestres fueron fértiles y el 82% produjo polluelos. Tres de los nidos produjeron nueve polluelos, ocho de los cuales volaron de los nidos en el bosque y uno se retuvo en cautiverio (Tabla 1, página 20). La Sociedad Nacional Audubon (Audubon National Society), patrocinó a seis voluntarios para que ayudaran al personal del proyecto a proteger los nidos activos.

La población de cotorras alcanzó la cifra récord de 41 individuos (incluyendo tres polluelos que todavía se encontraban en uno de los nidos), al final de la temporada de reproducción de 1987. A cada polluelo (cinco machos y tres hembras) se le colocó un radiotransmisor y una banda de metal numerada para estudiar su comportamiento, movimiento y supervivencia durante los primeros meses de vida fuera del nido. Dos polluelos volaron del nido de "West Fork" (WF). Uno de los polluelos, aparentemente, fue atrapado por ave rapaz cinco días después de volar del nido. El otro polluelo se movió con la bandada, por un mes, antes de que el transmisor fuera encontrado. Aparentemente, el hilo utilizado para mantener el transmisor en su lugar se rompió y el transmisor se desprendió del polluelo.

Tres polluelos con radiotransmisor volaron del nido de SF#1 a finales de junio. Una de las señales desapareció en julio y no se pudo determinar el destino del polluelo. Los otros polluelos se mantuvieron en el área de "South Fork" hasta finales de septiembre. En septiembre, los polluelos comenzaron a moverse hacia otros valles en el bosque. Uno de los polluelos regresó al valle de "South Fork" después de una semana. Sin embargo, la señal comenzó a debilitarse rápidamente y fue imposible continuar siguiéndolo. Durante una búsqueda de las señales, sobrevolando el bosque con una avioneta, encontramos la señal del otro polluelo en un área de difícil acceso. Un día después se encontraron los restos del polluelo en avanzado estado de descomposición, por lo que no se pudo determinar la causa de su muerte.

Los tres polluelos del nido de SF#2 se mantuvieron en el área de "South Fork" junto con los polluelos de SF#1 durante el mes de julio. A finales del mes de julio, los polluelos de SF#2 comenzaron a moverse con la bandada. Durante el mes de septiembre, los polluelos alternaron sus movimientos entre el área de "South Fork"

y las áreas de "East Fork/West Fork/Caimitillo" en el lado este del bosque. Sin embargo, en algunas ocasiones las señales no pudieron ser localizadas en las áreas tradicionales. Aparentemente, los polluelos utilizaron áreas dentro del bosque de Luquillo, que nosotros desconocemos. La señal de uno de los polluelos no pudo ser localizada después de mediados de septiembre y no se pudo determinar el destino del polluelo. A principios de octubre, los otros dos polluelos se separaron de la bandada y permanecieron separados por varios días. A finales de octubre, uno de los polluelos se unió a la bandada nuevamente. El otro polluelo permaneció en el área de caimitillo hasta el 10 de noviembre, cuando la señal dejó de indicar movimientos. Los restos encontrados indicaban que el polluelo fue capturado por un ave rapaz. La señal del polluelo sobreviviente se debilitó hasta perderse, en el mes de noviembre.

Al final de la fase de campo del estudio de telemetría se habían recuperado los restos, junto con los transmisores, de tres polluelos. Además, se encontró un radiotransmisor sin evidencia, que indicara lo ocurrido al polluelo. Los otros cuatro transmisores dejaron de funcionar.

Población en Cautiverio

En 1987, cuatro parejas de cotorras (dos parejas más que en 1986) produjeron huevos fértiles. Estas parejas produjeron 23 huevos en total, incluyendo los huevos producidos por dos parejas que fueron inducidas a anidar dos veces. De los 23 huevos producidos, 13 eran fértiles y cuatro de los huevos produjeron polluelos (Tabla 2, página 21). Las hembras de otras cuatro parejas produjeron 14 huevos infértiles, incluyendo los huevos de una pareja que fue inducida a anidar dos veces. Los cinco polluelos (1 producido en uno de los nidos en el bosque y cuatro producidos en cuativerio) que se retuvieron en cautiverio, aumentaron el total de cotorras cautivas a 41. En la actualidad, la población de cotorras en cautiverio se compone de cuatro parejas productivas, 15 cotorras (cuatro machos y 11 hembras) de edad suficiente pero que no se reproducen y 18 juveniles (13 machos y cinco hembras). Dos de los polluelos producidos en el nido de SF#1 desarrollaron problemas de crecimiento. Aunque recibieron el cuidado intensivo de un veterinario en el aviario, los dos polluelos murieron.

Cuatro de las parejas de cotorras dominicanas (*Amazona vittata*) produjeron 12 polluelos (Tabla 2, página 21). Estos polluelos aumentaron el número de cotorras dominicanas en el aviario de Luquillo a 60 (33 machos, 23 hembras y cuatro de sexo desconocido). Siete cotorras puertorriqueñas y 22 dominicanas, están separadas para ser utilizadas por el Departmento de Recursos Natrurales de Puerto Rico, en el futuro programa de reproducción en cautiverio de Río Abajo. La separación de estas cotorras es parte de un acuerdo entre el Departamento de Recursos Naturales de Puerto Rico y el Departamento de Pesca y Vida Silvestre de los Estados Unidos.

En el pasado, la mayoría de las cotorras puertorriqueñas hembras no han producido huevos fértiles debido a la falta de machos para aparearlas, o a la inefectividad de los machos con los cuales están apareadas. Utilizando inseminación artificial, es posible que se pueda incrementar la producción y la variabilidad genética de la población cautiva. En 1987, experimentando con inseminación artificial, se produjo un huevo fértil de cotorra dominicana. La producción de este huevo fértil mediante inseminación artificial, está considerado como uno de los mayores avances en el programa de reproducción en cautiverio. Aparentemente, el semen de calidad adecuada solo se puede obtener de machos que estén apareados. Por lo tanto, la recolección de semen puede interferir con el proceso de reproducción normal. La data que se coleccionó en 1987 proviene de muestras muy pequeñas. Para el próximo año, se planean llevar a cabo experimentos más rigurosos, para investigar la viabilidad de la utilización de la inseminación artificial para aumentar el número de cotorras puertorriqueñas.

Este año se condujo un experimento en coordinación con Avi-Sci Inc., para determinar los requerimientos nutricionales de las cotorras cautivas. Uno de los objetivos del experimento, era eliminar la posibilidad de que la baja reproducción de las cotorras cautivas se deba a deficiencias en la nutrición. Se utilizaron cuatro diferentes dietas para alimentar un grupo de cotorras dominicanas. Se coleccionaron datos sobre la cantidad de alimento consumido diariamente. Se pesaron los individuos y se coleccionó material fecal cada tres meses. La colección de datos terminó en diciembre de 1987. Se espera que se produzca el informe con los resultados finales en 1988.

En 1987 se realizaron mejoras en el aviario. Se desmanteló y removió el antiguo aviario de las cotorras dominicanas y la jaula de los juveniles ("flight cage"). Se intalaron 44 jaulas "Noegel" (1.2 m ancho x 1.8 m largo x 1.2 m alto) sobre bases en cemento. Se construyeron dos jaulas para juveniles cerca de la casa de La Mina. Se añadió una jaula para gallinas "batam". Las gallinitas serán utilizadas para incubar los huevos de cotorra. Las renovaciones fueron terminadas a finales de diciembre.

En 1987 fue publicado el libro "The Parrots of Luquillo: Natural History and Conservation of the Puerto Rican Parrot" por "The Western Foundation of Vertebrate Zoology", Los Angeles, California. Los autores Noel Snyder, James Wiley y Cameron Kepler, fueron los primeros tres líderes del proyecto para la recuperación de la cotorra puertorriqueña. La monografía es una recopilación abarcadora de la investigación científica y los esfuerzos de manejo que se han llevado a cabo desde los comienzos del programa de conservación para la recuperación de la cotorra puertorriqueña.

Reconocimiento

El proyecto de la cotorra es un esfuerzo interagencial. Los autores agradecen el esfuerzo y dedicación de Carlos Laboy (Departamento de Recursos Naturales), el personal del Servicio Forestal de los Estados Unidos: Marc Bosch, Víctor Cuevas y Orlando Carrasquillo (Bosque Nacional del Caribe), Giovani Cabán, Oscar Díaz y Orlando Rivera (Instituto de Dasonomía Tropical) y al personal del Departamento de Pesca y Vida Silvestre de los Estados Unidos: Fernando Núñez, Hernan Abreu, Betsy Anderson, Tyrone Medina, Irving Ortíz, Maureen Rowe, Mónica Tomosy y Edgar Vázquez.

CONDICIONES Y USO DE NIDOS POR LA COTORRA PUERTORRIQUENA EN 1987, USO DE NIDOS MANIPULADOS DESDE 1968 HASTA 1987 BOSQUE NACIONAL DEL CARIBE

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Para el 1987 existían 45 estructuras de nidos de cotorra puertorriqueñas provistos por el personal del proyecto y disponibles para la población silvestre de cotorras de Puerto Rico (*Amazona vittata*). Treinta y dos de estos nidos fueron nidos artificiales de cloruro de polivinil (PVC) y 13 fueron cavidades naturales mejoradas. Todos los nidos se encontraban ubicados en tres áreas de anidaje de cotorras tradicionales: West Fork, East Fork y South Fork. Las cavidades naturales mejoradas se encontraban en árboles de palo colorado (*Cyrilla racemiflora*) y al igual que los nidos de PVC fueron preparados a prueba del clima y mejorados de tal forma que proveían estructuras óptimas de anidaje con relación al tamaño, apariencia, lugar donde posarse, interiores y otros.

En el 1987 tres de estos nidos fueron usados por cotorras en reproducción. Dos fueron nidos artificiales y el otro fue una cavidad natural mejorada. Solo dos de estos nidos fueron eventualmente exitosos, cinco polluelos de cotorra volaron de los mismos. Además, una pareja nueva anidó en una cavidad natural en un árbol de palo colorado y produjo tres polluelos de cotorra (ver Tablas 1 y 2, páginas 23 y 24 y la Figura 1, página 24).

De los 45 nidos provistos por el proyecto, disponibles en 1987, tres fueron usados por las cotorras y 23 quedaron disponibles sin usar. Durante el año, 13 nidos fueron utilizados por zorzales pardos (*Margaropsfuscatus*) en diferentes intervalos de tiempo, 8 por abejas (*Apis mellifera*) y uno por ratas negras (*Rattus rattus*). La ocupación de los nidos por un competidor generalmente ocurre después del período en el cual la cotorra selecciona su nido, entre enero y febrero, y probablemente tiene muy poco impacto, si alguno, en la selección de nidos por la cotorra. Todos los nidos fueron cerrados al final de la temporada de anidaje de las cotorras para prevenir el uso de los mismos por los competidores en el período fuera del apareamiento.

Luego de la temporada de apareamiento se hicieron reparaciones mayores en el nido activo de West Fork. Debido a que el árbol, en el cual dicho nido de PVC se encontraba, esta próximo a morir y caer, el nido fue removido e instalado en un poste de metal de forma tal que su posición permanece siendo la misma. Al mismo tiempo se reparó el nido, se mejoró a prueba de interperie y se añadió una nueva liana a la entrada del mismo.

Mejoras mayores se hicieron también a la nueva cavidad natural en el área de South Fork. El nido se hizo a prueba de interperie, se añadió un fondo de tela metálica ("screen"), aserrín de palo colorado como material de anidar, se añadió también una visera y una liana a la entrada del nido y se construyó una puerta de acceso al fondo del nido para facilitar la inspección. Todos los otros nidos también recibieron mantenimiento al finalizar la temporada de apareamiento. Las necesidades de mantenimiento más comunes fueron el colocar nuevas lianas a la entrada del nido, viseras, cambiar la tela metálica en el fondo del nido, cambiar goznes de las puertas de acceso y colocar peldaños para subir a los árboles.

Durante el 1987 dos árboles que sostenían nidos artificiales de PVC se cayeron. Estos nidos nunca fueron utilizados por las cotorras, uno de ellos mantuvo un panal de abejas por varios años. Estos nidos serán removidos y reparados para uso futuro.

Existen actualmente 44 nidos, provistos por el proyecto, disponibles para la cotorra en apareamiento durante esta temporada 1988. Treinta son nidos artificiales de PVC y 14 son nidos productos de cavidades naturales mejoradas en árboles de palo colorado. Ocho nidos se encuentran en el área de anidaje de West Fork, 23 en el área de East Fork y 13 en el área de South Fork. Todos estos nidos han sido reparados, abiertos al uso y provistos de material seco para el fondo del nido. A partir de la información demográfica disponible sobre la población de cotorras y del número de parejas que se formaron en 1987 (8), existe un potencial excelente para esperar obtener este año (1988) un número mayor de cotorras apareadas que las cuatro obtenidas el año pasado (1987).

La población silvestre de cotorras de Puerto Rico ha continuado aumentando desde el 1975, cuando solo existían 13 individuos (Tabla 3, página 25 y Figura 2, página 25). A finales del año 1987 la población

silvestre se estimaba alrededor de los 35 individuos.

Durante los últimos 20 años, diez de los nidos manipulados han sido actualmente usados para la reproducción por las cotorras (hasta por lo menos la etapa de huevo, ver Figura 3, página 25). Desde el 1968 hasta el 1974 solo se utilizó un nido manejado por año. Desde el 1975 en adelante, de tres a cinco nidos manejados han sido utilizados para la reproducción en cada año. De estos 10 nidos, siete son nidos en cavidades mejoradas de palo colorado y tres son nidos de estructuras de PVC. De los 65 intentos de anidaje ocurridos en estos 10 nidos (un nido fue utilizado 10 veces para producir una segunda nidada en un año dado) desde el 1968, 34 han sido en nidos de PVC y 31 han sido en cavidades naturales o cavidades naturales mejoradas. Durante este período de 20 años, las cotorras que utilizaron estos 10 nidos produjeron un mínimo de 195 huevos y 95 polluelos volaron de estos nidos, incorporándose a la población silvestre (Fig. 4, página 26).

ACTIVIDADES DEL ASESOR FORESTAL REGIONAL

Loren B. Ford
Bosque Nacional del Caribe

El asesor forestal regional del Caribe (Loren B. Ford) es un miembro del personal del Bosque Nacional del Caribe y está asignado a proveer y coordinar la asistencia técnica forestal a las misiones de la Agencia del Desarrollo Internacional de los Estados Unidos (US-AID) en la cuenca del Caribe y además, coordinar para Latino-América y el Caribe el programa del Servicio Forestal de Estados Unidos para la dasonomía tropical. La razón más importante de que este consultor está estacionado en Puerto Rico es la de integrar las actividades internacionales con el Instituto de Dasonomía Tropical, buscar oportunidades para transferir los resultados de investigación a otros países de la cuenca del Caribe e identificar las necesidades de investigaciones internacionales de dasonomía para ser consideradas como parte del portafolio de investigación del Instituto.

Alrededor de un 50% del tiempo del asesor se utiliza en viajar, en respuesta a las necesidades de las misiones de la Agencia del Desarrollo Internacional (US-AID) y su trabajo relacionado, así como los viajes realizados y los resultados obtenidos durante el año fiscal 1987 se informan en la Tabla 1 (página 29). Otras actividades incluyen la co-edición de las actas de la Tercera Reunión de Dasónomos del Caribe llevada a cabo en Guadalupe, Antillas Francesas del 19 al 23 de mayo de 1986 (veáse la lista de publicaciones del Instituto); se editó y publicó el *Hogplum Gazette*, carta informativa del Capítulo del Caribe de la Sociedad Internacional de Dasónomos Tropicales.

Appendix
Apéndice

A. Current Institute publications.
(*indicates reprints available for distribution).

Publicaciones recientes del Instituto.
(* indicación de reimpresos disponibles para divulgación).

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Francis, J.K. 1986. Nutrient depletion by intensive harvest of southern bottomland hardwoods. Page 151 *in* Program of the IV International Congress of Ecology. August 10-16, 1986. State University of New York, Syracuse University, Syracuse, New York. (Abstract).

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Table 1. Activities Institute staff participated in during FY 1986-87.

Commonwealth of Puerto Rico	National	International
-Assessed extent of physiological damage to mangroves affected by airplane fuel spill in Roosevelt Roads.	-Reviewed papers for several national journals and granting agencies.	-Presented paper on patterns of nutrient accumulation and release in Amazonian forests of the Río Negro Basin at the Symposium on Mineral Nutrients in Tropical Forests and Savannas in Stirling, Scotland.
-Several ecology training courses to high school science teachers.	-Presented paper on tropical forestry, North Central Forest Experiment Station, St. Paul, Minnesota.	-Presented papers at the Second International Symposium of the Sociedad Ornitológica de Puerto Rico.
-Advised Science Teachers' Association.	-Assessed Biosphere Reserve Nominations from Cuba; U.S. MAB Program, Washington, D.C.	-Assisted Island Coordinator, International Council for Bird Preservation, in completing information on threatened, vulnerable, rare and endangered vertebrate fauna in the Caribbean.
-Short course on statistics to high school science teachers at the University of Puerto Rico.	-Supplied ornithological species and site information to Dr. Luis Baptista, California Academy of Sciences.	-Supplied ornithological species and site information to head of "Bird Bonanzas", a group that leads international cruises in quest of endemic, native and rare birds.
-Lectured on nutritional relationships of plants under hydric and nutrient stress on tropical mountains at University of Puerto Rico (Río Piedras and Cayey campuses).	-Taught tropical ecology course for mainland college teachers.	-Hosted workshop on Caribbean wetlands.
-Lectured on tropical ecology at Cupeyville High School, Río Piedras and several other high schools in Puerto Rico.	-Advised Yale's School of Forestry and Environmental Studies on tropical programs.	-Presented paper at world conference on island development.
-Advised high school students on science projects for fairs and classes.	-Gave presentation at a Chief's (U.S. Forest Service) Seminar.	-Advised the Canada National MAB Committee.
-Advised Terrestrial Ecology Division of Center for Energy and Environment Research on root ecological research.	-Advised the U.S. Forest Service Chief's Office on the planning of a national workshop on air pollution.	-Presented paper at Caribbean Wildlife Symposium.
-Editor, *Acta Científica*, the journal of the Science Teachers' Association of Puerto Rico.	-Hosted workshop for scientists in National Science Foundation's Long-Term Ecological Research Program.	-Supplied ornithological life-history and site information to Dr. Peter Wood, International Council for Bird Preservation.
-Taught graduate course on plantation forestry at the University of Puerto Rico.	-Lectured at Rhode Island's School of Oceanography.	

Table 1. (cont'd).

Commonwealth of Puerto Rico	National	International
-Lectured to student bodies of: Turabo College, Interamerican University at Ponce, Catholic University at Ponce, Sagrado Corazón University, and Metropolitan University.		-Supplied ornithological information to various Ph.D. students new world species.
-Gave a 15-minute public television narrative on the historical decline of the endangered Puerto Rican Parrot, recovery steps and most recent advances in the restoration program.		-Served on editorial board of *New Forests*, Amsterdam, Netherlands.
-Presented a slide show entitled "Vertebrated Wildlife of the Caribbean National Forest" to Cub Scouts and their families in Ponce, followed by a field trip.		-Presented talks on hurricanes/secondary forest survey and management at COHDEFOR (Corporación Hondureña Desarrollo Forestal), Siguatepeque, Honduras.
-Presented lecture on hurricane damage, growth and species changes in colorado forest to ecology classes at the University of Puerto Rico, Cayey Campus.		-Hosted group of foresters and technicians from Guadeloupe.
-Provided professional counsel to the Secretary of Natural Resources, Government of Puerto Rico.		-Hosted Kadga Basnet, Nepalese student attending the Ecology Program at Rutgers University, New Brunswick, New Jersey.
-Presented paper at Coastal Workshop of the U.S. Corps of Engineers.		-Taught hydrology course at Zaragoza, Spain.
-Presented lectures on forest management at School of Guards of the Puerto Rico Department of Natural Resources at Gurabo.		-Presented paper at a restoration workshop in Budapest, Hungary.
-Provided professional counsel on urban forestry, Office of the Mayor, San Juan.		-Presented paper on mangrove ecology at Cananea, Brazil.
		-Editor, *ISTF News*, Society of American Foresters, Washington, D.C.
		-Advised and reviewed newly drafted forestry and wildlife legislation of Montserrat.
		-Editorial board of various international journals.

Table 1. (cont'd).

Commonwealth of Puerto Rico	National	International
-Led the Natural History Society on a forest management field trip to Luquillo Experimental Forest. -Presented paper on the history of the Luquillo Experimental Forest, Forest Service Seminar at the Interamerican University. -Served on panel, seminar on island biology, Interamerican University.	-Presented paper on research needs, Rockefeller Foundation, New York.	-Presented paper at 4th World Wilderness Congress in Denver, Colorado.

Table 2. Committees or delegations with Institute staff participation. Chairmanship by Institute staff is indicated by (*).

Commonwealth of Puerto Rico	National	International
-Judges for environmental section of the State Science Fair in San Germán.*	-Member, long-term ecological research and management team for Puerto Rico and U.S. Virgin Islands. Project sponsored by United States Department of Interior National Park Service and the U.S. Virgin Islands Fish and Wildlife Service on St. Croix.	-Coordinator, Silvicultural Study Group, North American Forestry Commission, Chetumal, Mexico.
-Executive Committee, Natural History Society, San Juan.	-Vice-President: attended four meetings, Caribbean Conservation Association, Barbados, West Indies.*	-Co-chaired a workshop on Tropical Silviculture and Management, North American Forestry Commission, Chetumal, Mexico.*
-Science Subcommittee on Parrot Research.	-Member, Awards Committee, American Forestry Association, Washington, D.C.*	-Membership on Commission on Ecology, International Union for Conservation of Nature and Natural Resources, Gland, Switzerland.
-Senior Science Advisory Committee of the President of the University of Puerto Rico.*	-Three meetings, Eastern Caribbean Natural Area Management Program, St. Croix, Virgin Islands.*	-Environmental Science Judge for International Science Fair.*
-Sea Grant Program Advisory Committee of the University of Puerto Rico.	-Puerto Rican Parrot Recovery Team.	-Research Committee of the Food and Agriculture Organization of the United Nations (FAO) Latin American Forestry Commission.*
-Graduate Student Committee at the University of Puerto Rico.	-Puerto Rican Parrot Inter-Agency Working Group.	-Councilor, Association of Tropical Biologists
	-National Technical Wetlands Council.	
	-U.S. Man and the Biosphere Program: •Directorate on Tropical Forests* •Directorate on Caribbean Islands.	
	-Affirmative Action Advisory Committee (AAAC), USDA Forest Service, Southern Forest Experiment Station.	

Table 3. Visitors to the Institute of Tropical Forestry.

Pedro Acevedo
New York Botanical Garden
Bronx, New York

Khadga Basnet
Ecology Program
Rutgers University
New Brunswick, New Jersey

James E. Bell
USDA Forest Service
Southern Forest Experiment Station
New Orleans, Louisiana

Frank Besosa
San Juan, Puerto Rico

David Blockstein
Department of Wildlife Ecology
University of Wisconsin
Madison, Wisconsin

Sandra Brown
Department of Forestry
University of Illinois
Urbana, Illinois

Bruce Cabarle
Santurce, Puerto Rico

Alan Covich
Department of Zoology
University of Oklahoma
Norman, Oklahoma

Alex Cruz
Department of Biology
University of Colorado
Boulder, Colorado

Bolair Csuti
Lake Oswego, Oregon

George Dale
Department of Biology
Fordham University
Bronx, New York

Nora Devoe
School of Forestry and
Environmental Studies
Yale University
New Have, Connecticut

Robert Erickson
USDA Forest Service
Region 8
Atlanta, Georgia

Edgardo González
Puerto Rico Department of
Natural Resources
San Juan, Puerto Rico

Robert Granthan
Department of Biology
University of Colorado
Boulder, Colorado

Enrique Hernández
Department of Biology
University of Colorado
Boulder, Colorado

Wayne Hunt
USDA Forest Service
Southern Forest Experiment Station
New Orleans, Louisiana

Richard Ince
Forest Resources Associates, Inc.
Shelburne, Vermont

Sri Barethie Kennie
Sri Lanka

Manuel La Rosa Musante
Sociedad Paramonga LTDA, S.A.
Lima, Peru

George Ledec
Panama

Gene Likens
Institute Ecosystem Studies
New York Botanical Garden
Milbrook, New York

Table 3. (cont'd)

Jeffrey L. Lincer
Eco Analysits, Inc.
Sarasota, Florida

Frank M. McCormick
Department of Ecology
University of Tennessee
Knoxville, Tennessee

Mayo Mohs
Rockefeller Center
New York, New York

Jorge Moreno
Department of Biology
University of Colorado
Boulder, Colorado

Juan E. Muñóz
Puerto Rico Department of
 Natural Resources
San Juan, Puerto Rico

Alejandro Novelo R.
Department of Botany
Institute of Biology
Mexico, D.F., Mexico

Ralf Olsen
San Juan, Puerto Rico

Bernie Parresol
USDA Forest Service
Southern Forest Experiment Station
New Orleans, Louisiana

John Parrotta
School of Forestry and
 Environmental Studies
Yale University
New Haven, Connecticut

Andre P. Plamondon
Quebec, Canada

Carlos F. Ponce
Conservation International
Lima, Peru

Enrique Quintana Lagos
Instituto Nacional Forestal y de Fauna
Zona Forestal "Alexander Von Humboldt"
Pucallpa, Peru

Blanca Ruiz
Boston, Massachusetts

Ricardo O. Russo
School of Forestry and
 Environmental Studies
New Haven, Connecticut

Tom Siccamma (plus 14 students)
School of Forestry and
 Environmental Studies
New Haven, Connecticut

Fred Sladen
US Fish and Wildlife Service
St. Croix, US Virgin Islands

U. Than Lwin
Forest Department
Rangoon, Burma

U. Thein
Forest Department
Rangoon, Burma

Teodoro Trucios Remolino
Instituto Nacional Forestal y de Fauna
Zona Forestal "Alexander Von Humboldt"
Pucallpa, Peru

Charlotte Taylor
Department of Biology
University of Puerto Rico
Río Piedras, Puerto Rico

Richard Tucker
Clark University
Worcester, Massachusetts

Marcha Ugamoto Nakamura
Instituto Nacional Forestal y de Fauna
Zona Forestal "Alexander Von Humboldt"
Pucallpa, Peru

Table 3. (cont'd)

Francisco Valenzuela
Mt. St. Helens Nat. Volcanic Monument
Pinchot National Forest
Ambay, Washington

Ana M. Vera
Boston, Massachusetts

José Villarubia
Puerto Rico Department of
Natural Resources
San Juan, Puerto Rico

Roland Wauer
National Park Service
St. Croix, US Virgin Islands

Holly Welles
School of Forestry and
Environmental Studies
Yale University
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